UNIVERSITY OF EDUCATION, WINNEBA

EFFECT AND INTERCONNECTIONS OF GHANAIAN ETHNOMATHEMATICS ACTIVITIES TO THE TEACHING AND LEARNING OF SCHOOL MATHEMATICS

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of the requirements for the award of the degree of Doctor of Philosophy (Mathematics Education) in the University of Education, Winneba

JULY, 2022

DECLARATION

STUDENTS' DECLARATION

I, Isaac Owusu-Darko, declare that this thesis, with the exception of quotations and references contained in published works which have all been identified and duly acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

SIGNATURE: ……………………………………

DATE: ……………………………………………

SUPERVISORS' DECLARATION

We hereby declare that the preparation and presentation of this work was supervised in accordance with the guidelines for supervision of dissertation as laid down by the University of Education, Winneba.

PRINCIPAL SUPERVISOR: PROF. DAMIAN KOFI MEREKU

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DEDICATION

I dedicate this thesis to my wife Mavis Ansah and my children Elsie Owusu-Agyeiwaa, Sebastian Owusu-Boateng and Janice Owusu-Agyarkobea

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LIST OF ABREVIATIONS

1	AAP	Academic Average Performance
2	ANOVA	Analyses of variance
3	AP	Average Performance
4	B.E.C.E	Basic School Certificate Examination
5	CBE	Complementary Basic Education
6	CERME	Conference of European Research in Mathematics Education
7	CRDD	Curriculum Research Development Division
8	CSPSS	Computerized School Placement And Selection System
9	ETHNOMATH	Ethnomathematics
10	FDG	Focus group Discussion Guide
11	GES	Ghana Education Service
12	HND	Higher National Diploma
13	HOD	Head of Department
14	ICE	nternational conferences on ethnomathematics
15	ICME	International Conference on Mathematics Education
16	IQ	Intelligent Quotient
17	ISGE	International Study Group on Ethnomathematics
18	JHS	Junior High School
19	JSS	Junior Secondary School
20	LMT	Literacy, Matheracy and Technoracy
21	MAFY	Managed Application Fiscal Year
22	NaCCA	National Council for Curriculum and Assessment
23	NALAP	National Literacy Accelerated Programme
24	RME	Realistic Mathematics Education
25	ROA	Relaxed Alertness, Orchestrated immersion, Active Processing
26	SHS	Senior High School
27	SPSS	Statistical Package for Social Sciences
28	SSCE	Senior Secondary Certificate Examination
29	SSS	Senior Secondary School
30	TESS	Techiman Secondary School
31	TEEE	Triangulation, Embedded, Explanatory, Exploratory mixed-

		design methods
32	TLM	Teaching And Learning Materials.
33	UEW	University pf Education, Winneba
34	WAEC	West African Examination Council
35	WASSCE	West African Senior Secondary School Certificate Examination

ABSTRACT

This study sought to investigate the effect and interconnections of basic Akan ethnomathematics activities that can support the teaching and learning school mathematics. The Ethnomathematics approach was demonstrated practically in a formal school stream to further investigate its interconnection with school mathematics, its effect on students „interest and perception of its integration in the teaching and learning process. The study adopted an explorative mixed research approach where both qualitative and quantitative methods were applied. The purposive and convenience sampling techniques were used to select 112 teachers from Techiman West and North Districts of the Bono-East region of Ghana with two adopted classes at Techiman Senior High School. The instruments used to collect data were observation, questionnaire guide, and interview guide and test scores for the analyses. A quasi-experiment design was employed. Content analyses, field exploration and statistical analyses using descriptive and inferential tests were done. Findings revealed that Akan communities had a lot of basic ethnomathematics, and their ethno-technological applications existed in various forms. This Basic ethnomathematics existed in the form of artefacts that could serve as resource-base in the teaching and learning of school mathematics. The ethnomathematics approach in teaching school mathematics was tested to have significant effect on student's academic achievement in the teaching and learning process, as reflected in the mean test difference of students' observed scores under t-test statistics. Though challenges and problems existed in making the interconnection of ethnomathematics to school mathematics, students and teachers perceived ethnomathematics integration in the formal teaching of school mathematics as useful. The integration of Akan ethnomathematics was seen to have significant motivation in building student interest in mathematics lessons. It was recommended that ethnomathematics application as a resource base and contextual applications be encouraged in the formal school mathematics lesson integration in the curriculum implementation process.

CHAPTER ONE

INTRODUCTION

1.0 Overview:

A lot of research has been done on Ghanaian mathematics education with respect to pedagogical skills appropriate to content development, methodology, content structure and curriculum among others. Little has been investigated towards the nature, role and effect of Ethnomathematics on the curriculum, content and pedagogical development of the subject. An area in mathematics education which is getting root in current research is ethnomathematics. It is a branch of mathematics which is used to express the relationship between culture and mathematics. The term is encoded into two compound words (ethno+mathematics). The term *ethno* describes all of the ingredients that make up the cultural identity of a group: language, codes, values, jargon, beliefs, food and dress, habits, and physical traits (D"Ambrosio, 1985). School mathematics expresses a broad view which includes arithmetic, classifying, ordering, inferring, and modeling. Exploring the interconnection of ethnomathematics to school mathematics under the formal curriculum implementation needs to be investigated.

The thesis is directed towards investigation of selected Ghanaian (dominantly among the Akans) basic ethnomathematics that has interconnections with school mathematics supporting curriculum implementation especially as an ingredient influencing the teaching and learning of formal mathematics.

This chapter discusses the background to the study, statement of the problem, purpose of the study, objective of the study, research questions and hypothesis. It further illustrates significance of the study, delimitations and limitations, organization of the study as well as definition of terms.

1.1 Background of the Study

Cultural diversity has been a pivotal phenomenon upon which a group of people live together. The ingredient of living together-encompasses the way they dress, eat, play, organize and educate young ones by transmitting culturally relevant knowledge from generation to generalization. One modern trend of mathematics education is the focus of the interplay of culture influencing the teaching methodologies in mathematics education. Pedagogical skills of the teacher are influenced by other strategies and structures of teaching mathematical concepts adapted from the socio-cultural precepts in the curriculum implementation process.

Every school is situated in a cultural environment. The socio-cultural perspective in doing school mathematics revolves around how people perceived mathematics to be. Mathematics is seen as a creative or inventive process, deriving ideas and suggestions from real problems. Ethnomathematics integration in mathematics teaching and learning reflects the cultural identity of the Learner. This approach helps to promote culturally responsive pedagogical choices for teachers in the curriculum implementation process (Wildfeuer, 2022)). Mathematics processes are based upon intuition, abstractions and contractions. Mathematics with its most abstract and powerful theoretical systems is linked to scientific process of nature explorations through the eyes of ethnomathematics approach as a tool for cultural evaluation and social representativeness (Silva, Palhares & Baptista, 2022).

Our ideas of mathematics depend so much on our own experiences and our own perception of the subject. Some may think of it as involving calculations, addition, subtraction, multiplication and division. Some may want to include topics like algebra, geometry, and trigonometry. Others may feel it involves logical thinking. From all these, mathematics is seen as being used in finding answers to questions and problems, which arise, in everyday life, trades and professions.

The informal and formal position of knowing mathematics is linked to satisfying six fundamental activities that are argued to be universal and carried out by every cultural group and is necessary for the development of mathematical knowledge: counting, location, measuring, designing, playing and explaining (Bishop 1988). Bridging the gap between informal and formal mathematical systems, typically from communities in which formal education systems still struggle with the native informal culturally relevant educational systems are paramount to researchers (Owens, 2017).

The current nature of school Mathematics as suggested by NaCCA (2019, p. 8) in the curriculum implementation process seeks to link mathematics pedagogical development with the competence of the child"s „cultural identity and global citizenship". African Mathematics educators observed that western science alone could not address all the needs of Africans. The current trend of mathematics teaching is conversionally westernized, eurocentic and whitish with little application to the learners cultural identity (Mereku, 2013). Basic Ghanaian ethnomathematics exist that can support the teaching and learning of school mathematics in various forms connecting informal and formal mathematization processes. Figure 1.1 shows some basic ethnomathematics conecting concepts of measurement, capacity, geometric games and tallying.

Figure 1.1: Some examples of Ghanaian indigenous Basic ethnomath activities on games measurement and artefacts.

The Ghanaians mathematical ideas are known by the most ordinary person in the market or home on ability to recognize quantity, measurement and shapes (Davis & Seah, 2016). Some of the mathematical concepts imprinted in certain Ghanaian cultures (predorminatly among the Akans) visualizes mathematical support to teaching school mathematics. They existed in the form of ethno-technological artefacts such as earth-bowls, games, measurement tools and tallying concepts as seen from Figure 1.1. Some of these basic ethnomathematics also are found to conncet the concept of congruence, parrallel lines, partterns, capacity and among others as seen from Figure 1.2

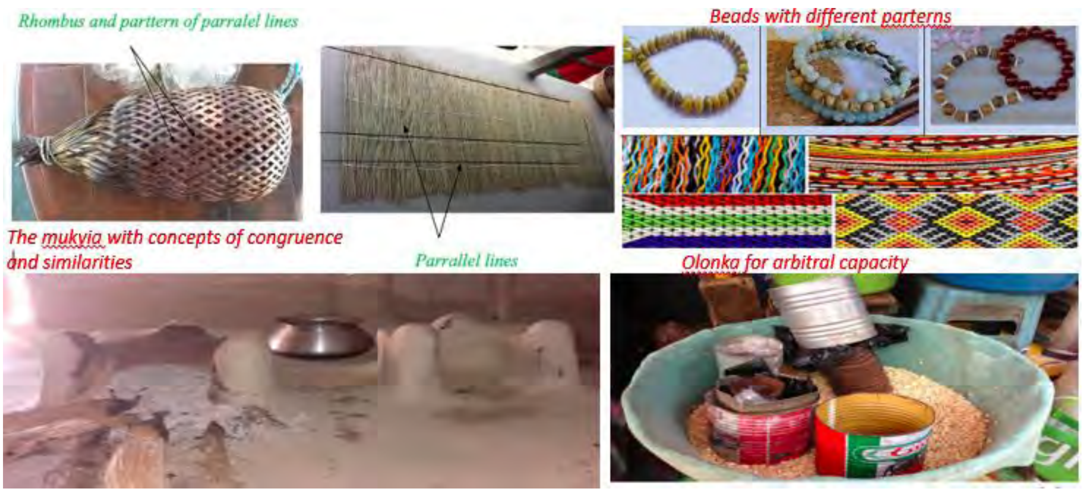


Figure 1.2: Some Ghanaian Basic ethnomaths linking some school math concepts

Some of the ethnomathematics exist in kitchen, fishing tools, mats, fashionable beads, and among others that can be used to teach school mathematical concepts like congruence, measurements, geometry etc. Similarly, there are other Geometrical shapes as seen from Figure 1.3 called Akan adinkra symbols that connect the notion of shapes, partterns and geometry. These artifacts existed in the form of traditional kente cloth and emblems of stools. These ethnomathematics can have formal school mathematical connections to the teaching and learning of mathematics in the curriculum implementation process.

Figure 1.3: Akan Kente and Adinkra symbols illustrating geometrical shapes

Some of the common Akan ethnomathematics can be deduced from traditional clothes (kente) designs and the Akan popular Adinkra symbols (as seen from Figure 1.3) percieved to descrbe proverbial situations that can be linked to the teaching of plane figures, words problem, measurements and mensurations. Mathematics teachers can connect school mathematical concepts teaching with these artefacts in the teaching of geometry, shapes and plane figures to bring about meaningful understanding of associated school curriculum standards.

Students‟ failure in mathematics may be attributed to teachings using methods that alienate our culture (Mereku, 2013). African communities have peculiar cultures and ethnomathematics rich with informal mathematics applications that can be used to teach school mathematics standards.

The connection between cultural diversity and subject-based concept teaching has been explored by several researchers (D‟Ambrosio, 1985; Bishop 1990; Orey & Rosa, 2016; Davis & Seah, 2016; Machaba, 2018; Sunzuma & Maharaj, 2019). The recent conversional method of teaching mathematics is westernized, eurocentric and whitish. Content-based knowledge in mathematics curriculum implementation process interest all stakeholders of the learner in every school. Teachers thrive to organize mathematics lessons in the best of ways to suit learners‟ understanding. Resourceful teaching demands the need to improvise, which resorts to Vygosky‟s (1934) socio-cultural theory. To make the teaching of mathematics meaningful, ethnomathematics is an emerging teaching philosophy with the naturalistic view which can help children from multicultural settings to cope with the understanding of mathematical concepts. Academic achievement is dictated by cultural influence. A student is allowed to engage in mathematics exploration and creativity for which the gist of the initiation is rooted from the school or community‟s culture. The diverse nature of culture is paramount in influencing the teaching and learning of scientific inquiry-based subjects of which mathematics is of no exception.

The origin of ethnomathematics is evident in the pioneering role of D‟Ambrosio (1985). Proponents and ways forward of the new area of mathematics philosophy relating to ethnomathematics education is of interest to researchers as recounted by Orey (2017). The implication of this phenomenon is in various mathematical pedagogies employed by mathematics educators and hence serves the bases of mathematics psychology in the classroom (Groh, 2018). Researchers in most mathematics pedagogies try to investigate various means by which mathematics teaching and learning would be appreciative to students. Teachers cannot look down upon cultural teachings especially from African context which triumph with rich culture (Davis & Seah, 2016). These cultural dynamics portray or perhaps, suggest good pedagogical approaches to the teaching of mathematics.

Various conceptual definitions have been given after D"Ambrosio master-minded the philosophical survey on ethnomathematics which interested researchers. The meaning of the "*ethno*" concept is extended throughout its evolution (D"Ambrosio, 1985). It has been viewed as an ethnical group, a national group, a racial group, a professional group, a group with a philosophical or ideological basis, a socio-cultural group and a group that is based on gender or sexual identity (Bishop, 1997). Rosa and Gavarrete (2017) define ethnomathematics as a program of studies relating to the cultural aspects of mathematics. Every individual is surrounded by cultural imprints one way or the other. Making sense of mathematics out of culture brings meaningful and exploratory learning grounded on the bases of what we know already and what culture has taught us. Culture will continue to teach us meaningful mathematics if mathematics teachers open up to admit its precepts to the implementation of the curriculum standards.

The connection between cultural diversity and subject-based concept teaching has been explored (Hermanto, Wahyudin, & Nurlaelah, 2019; Jeannotte & Kieran, 2017; Rosa & Orey, 2016; Tetteh, 2018). A focus on making a connection to the curriculum implementation has little concern to ethnomathematics integration. Several surveys have been done on ethnomathematics defined to be culturally influencing the mathematical approach to induce meaningful teaching and learning of mathematics. Kurumeh (2004) discusses the way in which students‟ immediate environment support ethnomathematics integration to teaching and learning of mathematics in schools. It is a good practice in Ghana to see dominantly many Ghanaian children attending community school existing in their immediate environments. Enukona (2002) admits to mathematical instruction that supports learners understanding when the learner‟s cultural background is considered for exemplification of mathematical problem-solving. The indigenous mathematics and euro-centric mathematics (modern classroom mathematics) need to be weighed to see what favours the African child than the European child. The assertion that mathematics is seen as white rather than black has been testified by (Bishop, 1997). There is the need to groom mathematics education for the African child based on culturally materialistic illustrations, examples and improvisations. The frontiers of curriculum implementers could start experimenting the ethnomathematics based philosophy to see the way forward of the mathematics education systems.

Ethnomathematics methodology should be embraced in our school system as part of the curriculum implementation. This would help capture students‟ interest in mathematics and challenge their brainpower to appreciate what they have as Africans. This will help make the content appealing to not only the learners but to those who teach it as well (Ozofor & Onos, 2018). Naresh (2015) asserts that our thinking about mathematics rarely brings the idea of culture to mind. Many mathematics educators believe that there is no place for cultural constructs in mathematics teaching and learning. There is a primary goal to find meaningful ways of bringing components of ethnomathematics into the formal curriculum mainstream (Naresh, 2015). The mathematics curriculum from the formal settings intensifies integrating ethnomathematical ideas into mathematics classrooms. Critical features are described in the formal mathematics curriculum that has a connection to the informal ethnomathematical perspective and ways of merging them are suggested when implementing. Some meaningful connections of ethnomathematics theory and practice are found in Ghanaian cultures that would help to address the critical canons of a critical ethnomathematics implication to the teaching and learning of Ghanaian core mathematics curriculum.

Mathematical constructs have been an existing phenomenon which guides curriculum development, adoption or adaptations. To some extent, these are guided by educational theories, principles and guidelines for any level in which the curriculum development is considered. One ideal factor which, to some extent could be undermined in Ghanaian situation is ethical consideration of ethnography of the people under which the mathematics curriculum is addressed. The interplay of ethnomathematics in understanding curriculum implementation and integration wealth a considerable concern to be investigated.

Ethnomathematics deals with both content and the process of curriculum implementation from informal perspective (Orey & Rosa, 2016). The curriculum structure is informed by the dictates of ethnomathematics since the learner is pioneered by what an immediate culture groom him or her. The learner is trained informally by parents through language by counting acquisition, games, lullaby, traditions and cultural artifacts that speak mathematical content before being exposed to the formal system of mathematics education. The ability to reconcile these formal and informal anthological knowledge based is the bone of contention which interest researchers.

Ethnomathematical study is particularly welcome at this time of heated debate about the future role of mathematics education in modern multi-cultural societies. This area of research is helping to shed light on the nature of mathematics itself from cross cultural, anthropological, and political, rather than philosophical, perspectives. Ethnomathematical study places itself as centroid to mathematics, cultural anthropology, and mathematical modelling (Orey, 2017). Ethnomathematics is a relatively recent field of study, in terms of being a coherent field. There have been many individual studies occurring over the last 50 years of the development of this research field. Few considerations of this multicultural influence on mathematics education have been considered in Ghanaian perceptive.

The pedagogical approaches mathematics educators adopt in bringing out teaching and learning must be guided by culturally mediation. Mathematics performance can be further complicated by the instructional approaches utilized by teachers. Culturally relevant pedagogy is one example of an instructional practice which integrates cultural referents (Amit & Quoder, 2017; Bhowmik et al., 2013; Knijnik, 2002).

The teaching and learning of mathematics is influenced by multilingual system of people. Language of the people is also a major factor in addressing ethnomathematics. The counting system of the Akan people for instance reveals many number concepts. A recent move towards the recognition of linguistic (language) and cultural diversity has created awareness for the discussion of researchers in regaining and reclaiming cultural identity (Abdullah, 2017; Davis, 2017; Elena, Villaverde, Victoria & Quiceno, 2019; Levanova et al., 2019). The multilingual system of Ghana where almost all geographical locations have peculiar language by which mathematical concepts and constructs are explained from ethnomathematics dispositions has implication on mathematics education. Researchers are of keen interest in looking at the cross-cultural variability of which this can have implications for number representation and processing. The olden number systems were solely deduced and transmitted from oral tradition where formal literacy had little existence. The limiting trend of these numeration systems from ethnographic point of view brought to some extent, ethnomathematics education orally transmitted from older generalization to younger generation and even to the current generation which experiences formal education.

There are several ethnomathematical informal contents hidden in the cover-sleeves of tradition presumed to have connection to the formal one. For example, geometry is vividly spelt out by cultural imprints in most of traditional artefacts (see Figures 1.1 and 1.2) the child is exposed to them first before been introduced to school mathematical systems. Culture and Geometry are interconnected, making school geometry closely related to the environment as well as the culture in which the mathematical concept is taught. This has been explored by many and sundry ethnomathematics researchers (Acharya, 2019; Fauzan & Husain, 2018; Muhammad et al., 2019; Sudirman et al., 2020).

This study explored the cross section of Ghanaian ethnomathematics from multicultural setups (predominantly among the Akan cultures) to find out the interconnections to school mathematics. The interconnection of the informal and formal position of mathematics is looked out. The various effect (to academic achievement, students and teachers" interest and motivation) associated to ethnomathematics integration to teaching and learning of school mathematics is investigated for the purpose of this study.

1.2 Statement of the problem

Mathematics seems to permeate all our human activities. Six fundamental activities that is argued to be universal are carried out by every cultural group and is necessary for the development of mathematical knowledge; counting, location, measuring, designing, playing and explaining (Bishop, 1988). Mathematics teaching has been taught in a conventionally westernized, eurocentric or whitish approach with absence of African cultural integration. Students" failure in mathematics may be even attributed to teachings using methods that alienate our culture (Mereku, 2013, Davis & Seah, 2016, Maharaj, 2019). The Ghanaian child education tries to dominantly alienate children from their cultural identity and hence impede on their understanding of the practicality of school mathematical content.

Mathematics educators thrive to find various pedagogical means of inducing understanding in mathematical lessons. To do so, several mathematics educators and in the field of their research propose constructivist and naturalistic views of teaching a lesson by considering cultural linkages to the development of mathematics pedagogy (Amit & Quoder, 2017; Bishop, 1997; D"Ambrosio & Rosa, 2017; Davis & Seah, 2016; Orey & Rosa, 2012). Even though theories surrounding ethnomathematics exist severally from international and national level, little has been done on integration of ethnomathematics approach (moves) in teaching mathematics in formal curriculum implementation process. A practical demonstration of this mathematics teaching strategy along cultural precepts needs to be further put in action most especially in Ghanaian perspective. Little research has been done towards ethnomathematics connecting the local cultures in Ghana (Davis & Seah, 2016; Mereku, 2013; Nabie, 2015; Okpoti, 2001).

Mathematics teaching has been taught in a conversionally westernized approach with absence of African cultural integration. The current existing literature offers theoretical framework for ethnomathematics (D"Ambrosio, 1985; Orey, 2004; Rosa et al., 2016; Davis & Seah, 2016; Mereku, 2013; Nabie, 2015). Various theoretical discussions have been made towards ethnomathematics philosophy. Few also connect findings to rich cultures of people they investigate. Little is seen connecting suggestions to teacher"s pedagogy (D"Ambrosio, 1985; Machaba, 2018; Sunzuma & Maharaj, 2019). The practical aspect of this ethnomathematics philosophy in African scientific research has not been considered so much (Mereku, 2013).

Mathematics education system in Ghana has been the concern of not only government but also general stakeholders who have child education at heart. Notwithstanding much hullabaloo on the fallen standard of education especially in mathematics, researchers investigate a lot on how to make the mathematics education learning friendly and teaching friendly. A new way researchers are looking up to is to consider the teaching of Mathematics in a cultural context (Oliveras, 2000; Rosa & Orey, 2016). The mathematics curriculum implementation depends largely on teachers" choice of pedagogical skills that would influence meaningful teaching and learning (D"Ambrosio,1985; Orey, 2016; Bishop 1990; Davis 2013). For the past decades, researchers portray research evidence on the bases of what theory has to say on ethnomathematics, but a practical demonstration of this philosophy is absent. This study focuses on the practical effect of ethnomathematics integration to teaching and learning of school mathematics on students" academic achievement, interest and motivation.

The curriculum specifies the subject scope of content and all that matters is for the learners to learn and teachers to teach in order to conform to the formal ideology of conventional Eurocentric philosophy of teaching and learning (Bishop, 2016). After all, the mastermind of this formal educational system is rooted from time antiquity within the colonial and neo-colonial era. What the western system defined for us is to be strictly adhered to the teaching of mathematics in the formal whitish form. It is high time Ghanaian mathematics educators began to reason out with the new and emerging mathematics educational philosophy of ethnomathematics integration in teaching school mathematics. A situation where the culture and social principles of the people are considered in designing and implementing the curriculum standards. This has not been truly considered most especially in Africa where rich cultural heritage is found. The child from the community in Africa (for example, typically Ghanaian) has cultural norms different from a child from Europe, America, and China and among other noted continents. Throughout history, the mathematics education curriculum has been designed, developed and delivered within Eurocentric philosophy (Scott, 2018).

The oppressive nature of mathematics is best described as Eurocentric (Adam, Alangui, & Barton, 2003; Rowlands & Carson, 2002). This conforms to the view of mathematics as primarily white, with European imagination and male genetically dominated. The mathematical constructs, concepts and ideas are western dominated in culture. A further investigation into the effect of ethnomathematics integration to teaching has little concern. This study makes such ideology practical by focusing on the need to use ethnomathematical integration in the teaching and learning of selected school mathematics to assess the extent of its impact on academic achievement.

Ethnomathematics and formal mathematical constructions have interconnected roles as instruments to model real world situations and events with cultural diversity (Rosa & Orey, 2016) as objects of reasoning. Mathematics is a particularly abstract domain because the affordances and constraints underlying the use of mathematical concepts may be different from the affordances and constraints in real-world situations (Cassar et al., 2019; Tetteh, et al., 2018; Wijayanti et al., 2019). Mathematical constructs teaching are perceived by many as difficult and can put interactors into some emotional dispositions in its mathematical engagements (Owusu-Darko, Ansah-hughes & Doe 2017). But irrespective of this, mathematics makes the acquisition of quantitative schemata a difficult task but also accounts for the potential to extend our understanding of the world by mathematical means. Students would be able to adjust to understanding mathematics through the lens of their culture. This could be done using the social-cultural theory implications (Vygosky, 1934). The study sought the opportunity to adopt quasi-experiment using ethnomathematics integration in teaching and learning to check on its impact on whether or not there would be a meaningful implementation of the curriculum process.

African researchers have demonstrated interest in exploring curiosity in cultural role in the teaching and learning of mathematics (Adomako, 2015; Khan, Francis, & Davis, 2015; Bishop, 2016). Some even focus their interest in the mathematical imprints in cultural dynamics of people in which formal education has been adopted over the informal one. In Ghanaian settings few surveys have been carried out under this direction. The existence of interconnection between ethnomathematics and formal education system in terms of the extent to which this phenomenon facilitates teaching and learning existed from antiquity. The general connection to mathematics curriculum adjustment is the concern for recent mathematics education researchers of which this study focuses. Mathematics educators" pedagogical skills is quite supported by what they see from their culture and environment especially in commanding literacy. Researchers try to develop resource modules and handbook that would facilitate the use of ethnomathematics in teaching (Forbes, 2018). This study focuses on using ethnomathematics handbook and theories to explore and demonstrate its impact in teaching and learning of school mathematics. Following the recommendation of Forbes (2018) handbook on ethnomathematics and its implication to teaching, this study operationalize the ethnomathematics integration as an approach in teaching school mathematics.

1.3 Purpose of the study

The purpose of the study is to explore Ghanaian basic ethnomathematics activities from multicultural settings (predominantly among the Akans), its interconnections and effect on the teaching and learning of school mathematics.

1.4 Objective of study

The main objective of the study is to explore Akan basic ethnomathematics activities and investigate their effect and interconnections to the teaching and learning of school mathematical concepts. It proposes to explore Akan basic ethnomathematics activities and experiment ethnomathematics approach of teaching to investigate its effect on students" academic achievement, effectiveness and usefulness of its integration as well as the interest and motivation associated with it usage.

The specific objectives of the study are the following:

1. To explore basic Akan ethnomathematical activities that can support the teaching and learning of school mathematical concepts.

2. To find out how Akan Ethnomathematics (informal) connect School-based curriculum mathematics (formal) teaching and learning.
3. To investigate the effect of ethnomathematics integration to teaching formal school mathematics on students" achievement in studying mathematical concepts.
4. To explore teachers" and students" perceptions of the effectiveness and usefulness of ethnomathematics integration in teaching and learning of school mathematics
5. To investigate the effect of ethnomathematics integration to teaching mathematics on students" interest and motivation in studying selected topics in Ghanaian core mathematics curriculum.
6. To investigate problems associated with the ethnomathematics integration in the teaching and learning of school mathematics.

1.5 Research questions

The following research questions guide the study:

1. What basic ethnomathematical activities are there in Akan communities that can support the teaching and learning of school mathematical concepts?
2. How does Akan Ethnomathematics (informal) connect School-based curriculum mathematics (formal) teaching and learning?
3. Is there any effect of ethnomathematics integration to teaching formal school mathematics on students" achievement in studying mathematical concepts?
4. What are mathematics teachers" and students" perception of the usefulness and effectiveness of ethnomathematics integration in teaching and learning of school mathematics?

5. What is the effect of ethnomathematics integration to teaching mathematics on students" interest and motivation in studying selected topics in Ghanaian core mathematics curriculum?
6. What problems are associated with the ethnomathematics integration in the teaching and learning of school mathematics?

1.6 Research Hypothesis

The research hypothesis is investigated on the bases of finding a significant effect of ethnomathematics integration in the teaching and learning of school mathematics. The study considered an inferential statistic for the following null hypothesis for research question three and five respectively:

H_{03}: There is no significant effect of ethnomathematics integration to teaching formal school mathematics on students" achievement in studying sschool mathematical concepts.

H_{05}: Students" interest and motivation in studying school mathematics curriculum is independent of ethnomathematics integration to teaching mathematics.

1.7 Significance/Implications of the study

The study would be useful to researchers on the basis of continuum theories or research on current trend of ethnomathematical studies. It would help researchers to look into the realms of how traditional indigenous mathematics educational imprints could suggest how curriculum is practically implemented without sidelining cultural heritage. Researchers are looking for areas of concern to sharpening the edges of mathematics education to widen its scope and to suggest means of addressing issues conflicting this area. Mathematics education researchers are looking beyond the classroom pedagogical skills governing the teaching and learning process and adopting external factors influencing the teaching of mathematics. Such effect is the ethnomathematical studies. A critical look of the interconnection between the ethno-informal educations to the curriculum focus of formal education would be useful enough to incite researchers in having interest to the field under study. Connecting mathematics to culture makes Africans feel at home and appreciate the role of their cultural heritage in the learning of school mathematics.

In addition, the study is directed in helping to streamline modalities that confront the teaching of mathematics especially by stakeholders in mathematics education. It is high time mathematics teachers look into what culture and traditions of the people guide teaching and learning. After all it is for the sake of the people to whom the school is situated and to liaise with what they are thought formally. Hence the study would inform teachers to bridge the gap between these two streams: curriculum and tradition.

The study would be of help to curriculum developers in Ghana. The Curriculum Research and Development Division (CRDD). In carrying out their role in designing syllabus for Ghanaian schools respective of levels, a consideration would be given to the role of ethnomathematics as bases to students‟ adjustment to their current trend of formal educational systems. Curriculum developers of Ghana [CRDD] in perspective would find this research useful when considering review of their formal curriculum structure for respective educational stages or levels.

It would be useful to stakeholders of education. The headmasters, school management committee (SMC), parents and teachers recognize the significant role of informal mathematics knowledge based to the formal one. There are a lot of parents who fancy the formal system of their wards education to the detriment of what their rich culture suggests. Their wiliness to transmit knowledge based from culture and tradition from what our forefathers has laid down has little respect and recognition. Parental role is needed in this direction in order to avoid undermining what the informal mathematical construct suggest. This study would help enlighten stakeholders of the essence of respecting the cultural heritage by merging formal and informal educational system through the eyes of ethnomathematics.

Teachers and students are found at the center of teaching and learning. The fulcrum of understanding mathematical construct and concepts could be influenced by not only teachers‟ pedagogical skills, but also relevant previous Knowledge (RPK) of the student. What has been given them from ethnomathematical point of view serves as foundation for advance teaching and learning from known to unknown.

1.8 Delimitation of the Study

The study was focused on upon gaining insight into ethnomathematics from Ghanaian perspective. Even though, Africans share dominantly many common traditions and cultures, the study is delimited to selected Ghanaian tribal communities predominantly among the Akans whom the researcher presumed to have ethnomathematical informal education trend reflective in their culture. Ethnomathematics considered include among others language through counting, artifacts from indigenous traditional technologies, traditional games and it connection to formal curriculum adjustment, implementation and adaptations. Students‟ response to how this ethnomathematics affect their formal mathematics classroom adjustment is looked out from the selected experimental school from which the tribes and communities is delimited.

The proposed experimentation of ethnomathematics approach of teaching to investigate its effect on students" academic achievement, effectiveness and usefulness of its integration as well as the interest and motivation associated with it usage is explained to only the chosen communities. It is however noted that there exist inter cultural mixing, inter-marriages and rural urban migration that most Ghanaian cultures have been interconnected somehow. Majority of the Akan culture is seen to be interrelated with other tribal communities and can host or extend other cultural elements and dynamics from or into its communities.

The integration of Ghanaian ethnomathematics is best to be introduced to the child education right from the early grade. The child most formal education starts from the primary school. Educating the child in formal arena alongside cultural integration help builds cultural identity and global citizenship (NaCCA, 2019). The study however considered the practicality of ethnomathematics integration to teaching formal mathematics from the secondary level. However, it could be introduced to other levels of the child"s education from the primary, Junior High School (JHS) and Senior High School (SHS) levels respectively. The limitation to ethnomathematics usage with respect to its integration to the teaching and learning of these levels is explained in section 1.9.

1.9 Limitations

A limitation to this study is the generalizability of ethnomathematics concepts for all Ghanaian schools. In the bid to explore ethnomathematics concepts and activities in the Akan communities that can support the teaching and learning of mathematics, the findings are peculiar to researchers chosen setting. The study and concept that is situated on multicultural systems and geographical locations peopled by students. Aside indisputable constraints such as inherent confounding variables, financial and time, other uncontrollable constriction beyond the control of the researcher may impinge restrictions on the conclusion of the study.

It is quite confusing to under- estimate ethnomathematics and the distinction not clear enough to dissociate ethnomathematics from resources-based teaching. The study is not to ensure ethnomathematics as improvisation, but to experiment on its pedagogical action (integration of ethnomathematics in teaching and learning) in Ghanaian classroom. Some other factors proposed to conflict the study may be data-gathering instruments ethnographic delusions and meta-analyses of ethnomathematics and its interconnection to mathematical concepts from formal settings. For example, not all mathematical symbols can be fully specified in Akan dialects in comparison to the formal way of teaching the subject. The need to mathematicise concept is paramount (Puni, 2019). It is good to start from somewhere so as to a point where mathematics would get it full support or grounds in cultural context integration to teaching and learning.

In as much as the researcher would minimize occurrence of biasedness, unwillingness of respondents to disclose a validated response to the given research instruments could falter the true results of the analyses. Again, the ethnomathematical move and its integration to school mathematics teaching is only piloted on some selected mathematical concepts from the SHS curriculum and not for entire generalizability. It is quite difficult to apply this to all mathematical concepts which is defined to conform to Eurocentric approach. The study only sought to pilot it pedagogy on selected mathematical concepts as demonstration lessons in a seeded school. To some extent, it is very difficult to exemplify some of the mathematical concepts in

Akan ethnomathematics. Making connection from informal idealization of mathematics to the most formal lessons may trigger or endanger pertinent meanings we have about mathematics teaching and learning. The findings however are implicative to mathematics educators in adding to existing search to find most prudent way of mathematics pedagogy.

1.10 Organization of the Study

The study is organized into five chapters. Following this first chapter of the thesis, the rest of the chapters are organized in the following discussions.

The remainder of this document includes: an extensive review of literature in Chapter 2; Chapter two highlights on review of literature of ideas of different authors whose findings might be defined in relation to the problem under study. The comprehensive literature review, the foundation of this study on Ethnomathematics, first provides a brief history of pedagogical practices which leads to the procedural approach that prevails in many classrooms worldwide. It then looks at the role of cultural pedagogy and indigenous mathematics in the classroom. Chapter 2 further, explores the meaning of ethnomathematics (cultural related mathematics pedagogy), and examines how an ethnomathematics approach lends itself to provide meaningful, evidential and inclusive mathematical construct linking the formal to informal. There is also intensive literature review of theoretical framework surrounding this thesis. The chapter ends by looking at some of the Ghanaian selected culture that portrays ethnomathematics supporting curriculum implementation guiding teaching and learning and general application of ethnomathematics in the classroom.

Chapter three focuses on methodological review, design and paradigm, sample and sampling techniques, research instruments, methodology behind data analyses as well as mathematical methods for the data analyses. Chapter 3 specifically outlines the research methodology and procedures guiding the research. It describes the main themes arising from the literature that guides the development of the research, especially looking at the population under study, sample and sampling techniques, research instrument used for the study, how data were collected and survey ways in which data would be organized, analyzed and interpreted in the subsequent chapter for of the study. Subthemes used to accomplish the objectives of the study are looked at.

The Chapter four deals with data analyses, result findings and discussions based on the study‟s research questions and hypotheses. A qualitative and quantitative data analyses is looked at using appropriate statistical descriptive and inferential discussions. Ghanaian traditional artifacts supporting ethnomathematics is discussed. Again, qualitative discussion of informal means of counting, number identification in comparison to the formal is critically looked at under content analyses in relation to number theory. Graph and tables and other diagrams where applicable are used to support the data analyses.

Chapter 5 culminates with a brief conclusive statement of the developmental study for which the study focused. In the same way, Chapter five will consist of summary, conclusion and recommendations. This is done in connection to other theoretical and conceptual frame work highlighted previously from literature in connection to other findings deduced from the data analyses. The thesis report however will end with references and appendices in supportive to the researcher‟s investigation.

All chapters are previewed and concluded with chapter synopses that summarizes each section discussions under various thematic considerations.

1.11 Definition of terms

1. *Adaptation*: In cultural theology and pedagogy, an approach which seeks to adapt traditional experiences in order to adjust to mathematical task or activity. It refers to how to adjust to mathematics engagement with the students maximum attention, (Owusu-Darko, Ansah-Hughes, et al., 2017)
2. *Contextualization*: The reception and rooting of the people"s particular cultural, political, economic or social context or situation to formal mathematics teaching
3. *Cultural activities:* Human regular doings, actions and events that exhibits cultural context; based on the way they live, knowledge, belief, art, morals, law, custom and any other capabilities and habits acquired by man in his adaptive environment.
4. *Cultural dynamics*: the different ideas and identities of cultural elements that exist in variations to support the teaching of mathematical ideas (ethnomathematics). They exist in the form of artifacts, music, games, and indigenous technologies and among others.
5. *Cultural elements*: The component parts of culture which make up the totality of a particular whole, like the Akan culture; referred to as the totality of ethos that is deemed to possess mathematical ideas.
6. *Culture:* It is the complex whole of identity which includes knowledge, belief, art, morals, law, custom and any other capabilities and habits acquired by man as a member of a society. Culture is the way a group of people live. It is through this culture identity and struggling for survivorship that allows people to think of ways to solve societal problems through indigenous technology master-minded by ethnomathematics ideas.

7. *Curriculum adaptations*: This refers to the process by which a subject based content (field of study) such as mathematics is revised or restructured to conform to societal needs (here considering the need to inculcate ethnomathematics from informal system to reconcile to the formal one.)
8. *Ethno-activities*: a short form of ethnomathematics activities to illustrate continual usage of practical actions of methodological activities adapted to the experimental class. It refers to traditions and culture that depicts ethnomathematics.
9. *Ethnogeometrical concepts:* Some cultural components that assumes ethnomathematics in the form of geometry. These cultural elements illustrate a link unto Euclidean geometric concepts. They turn to support application of geometry in the form of lines, circles, plane figures like rectangles, triangles, kites, parallelograms etc.
10. *Ethnomathematical moves*: pedagogical activities structured from culture dynamics of the people to illustrate informal mathematical constructions (ethnomathematics). These teaching activities follow a transition of the informal mathematical structure to link the most formal structure suggested by the curriculum implementations. These ethnomathematical moves are planned form of lessons the study uses to experiment and operationalize ethnomathematics in the classroom.
11. *Ethnomathematics actions*: Activities crafted on the bases of cultural ideas of ethnomathematics to demonstrate it influence from informal idealization of mathematical concepts to formal concepts. This is based of methodological activities ready to be demonstrated in the classroom as an „*action*‟ of teaching.

12. *Ethnomathematics activities*: Similar to *ethnomathematics actions,* practical outline of demonstrational lessons adapted from cultural dynamics of the people that is belief to support ethnomathematics of the people used for the study.
13. *Ethnomathematics*: a branch of mathematics which is used to express the relationship between culture and mathematics.
14. *Ethnomath:* a short form of ethnomathematics with similar meanings to mathematics seen from cultural context.
15. *Ethnomathematics pedagogy*–Pedagogical practices that incorporate diverse cultural practices into the teaching and learning of mathematics. (D'Ambrosio, 1985).
16. *Mathematical Reasoning*: Mathematical Reasoning is seen as a high-level cognitive process, which involves interrogating a problem or phenomenon to arrive at a reasonable result (Karataşa & Akyüzb, 2018)
17. *Geometrical knowledge*: mathematics concepts and ideas that are based on lines, areas, volumes and capacity. Mathematical concepts that illustrate Euclidean postulates of congruence of lines and angles. This mathematical concepts of *geometrical knowledge* can transcend from informal ethnomathematics to formal one.
18. *Mathematical construct*: the concepts to which mathematics content is based. The intuition behind mathematical principles, lemmas, formulas and theories guiding mathematics problem solving.
19. *Mathematical constructs*: It refers to *mathematical concepts* inherent in the formal and informal structure of mathematics education. The conceptualized framework of mathematics teaching and learning. The basic ideas of similarities abstracted from concrete to abstract upon which generalization is made, (Skemp,

1975). Mathematical construct can be viewed from primary mathematical concepts and secondary mathematical idealizations.

20. *Mathematics conceptualization*: Fundamental ideas of mathematics from primary concepts and secondary concept of mathematics
21. *Mathematization*: A way in which mathematical ideas is exemplified from ethnomathematics. When students mathematize, they describe a situation or problem using symbols which may include diagrams or graphs. They further manipulate the symbolic mathematical problem to understand the existing relationships or answer questions about the particular situations. Mathematizing is different from solving routine procedural problems. (Farokhah et al., 2017)
22. *Pedagogical actions:* they are teaching moves or activities demonstrated from the teachers most formal methodology planned for a particular instruction. It consists of the *trion* of teaching that is how instruction is introduced, the lesson is presented through series of activities and how the lesson is finally concluded or summarized. These activities are operationalized to transit from ethnomathematics idealization (informal) to formal mathematical conceptualization
23. *Pedagogical moves*: Similar to pedagogical actions, a situation in which the teacher pedagogy planned for the lesson is operationalized in the classroom from introduction to the conclusion of the lesson through ethnomathematics demonstrational lesson to integrate interaction of formal and informal mathematics conceptualization.
24. *Traditional indigenous artifacts:* Material things found from Ghanaian homes and communities traditionally engineered to solve problems or for societal needs.

25. *Mathematical Reasoning*: A high-level cognitive process, which involves interrogating a problem or phenomenon to arrive at a reasonable result.
26. *Mathematical Task*: A mathematical task refers to whatever a teacher uses to demonstrate mathematical concepts, engage students in interaction or request students to do something, such as homework problems and classroom activities on their own or in a group. Tasks may also include any student-initiated action in response to a given situation, (Forbes, 2018)

1.12 Chapter Summary

This chapter gave an introduction to the thesis report highlighting on issues relating to background of the study, statement of the problem, purpose of the study, objectives and research questions guiding the study, delimitations and limitations as well as significance of the study. In addition to these are definitions of terms that serves the bases of the thesis report as well as given an overview of the organization of the study. The chapter concludes with this summary.

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview:

This section discusses a literature review on scholarly articles, journals, periodicals, thesis, dissertations and other existing literature in relation to the topic under discussion. In this chapter, there is a review of the work of several authors concerning concept definitions of ethnomathematics, theoretical framework surrounding ethnomathematics and mathematical constructs. There is a review of empirical framework on various research carried on ethnomathematics as a research program and paradigm. The chapter develops conceptual frameworks surrounding the research in the chosen area. There is a review of various researches done to uncover the role of ethnomathematics in mathematics education. Researches, empirical work and authors" opinion are looked at.

2.1 Origin of Ethnomathematics and Concept definitions

Ethnomathematics is rooted from a blend of words to deduce a contextual meaning relating to a link of culture and mathematics. The culture of people refers to the way by which a group of people lives, elemented by several common characteristics such as language, the way they eat, play, entertain, educate, perform ceremonies and among other several social indicators. Ethnomathematics is a cultural elements indigenously rooted to surrounds technology and civilization, (Maryati & Prahmana, 2019; Pramudita & Rosnawati, 2019a; Supiyati et al., 2019). Ethnomathematics has been a research area in the history of mathematics education with pedagogical implications which has received organizational framework initiated by (D"Ambrosio, 1985), philosophical study in making educators aware of the need to consider the cultural role of the people when teaching mathematics. This linkage between mathematical imprints found among some culture (s) from informal position have been pioneered by the work of (Ubiratan D‟Ambrosio, 1985) upon which several authors have continued a further search and in-depth study on several implications to mathematics education (Bhowmik et al., 2013; Rosa et al., 2016.; Rosa & Gavarrete, 2017a; Rosa & Orey, 2016; Stathopoulou, 2017). D‟Ambrosio asked himself rhetorically, the meaning of Ethnomathematics and concluded that, it

> *"…is a research program in the history and philosophy of mathematics, with pedagogical implications, focusing the arts and techniques [tics] of explaining, understanding and coping with [mathema] different socio-cultural environments [ethno],* (D‟Ambrosio, 2001, p. 16)

The term ethnomathematics has been encrypted into two multifaceted words (ethno+mathematics). From the word ethnomathematics, the word "ethno" defines "all of the constituents that make up or form the basis of the cultural characteristics of a group of people: language as a medium of communicating mathematical concepts, codes that deduce symbols, values, and jargons forming the basis of cultural diversity, beliefs, staple food and people‟s dress codes that identify them. Also the habits as well as physical traits that identify the group upon which the culture relates (D‟Ambrosio, 2001). Ethnomathematics articulates a "broad view of mathematics which includes arithmetic, classifying, ordering, inferring, and modeling," (D‟Ambrosio, 2001, p. 27). The curriculum structure from pioneering formal education system in Ghana, for example, had content familiar to what D‟Ambrosio (2001) seeks to define.

Ethnomathematics to some extent conforms to the theory of evolution which emerges from socio-cultural doctrines as a seed and grows to a broader extent until it converges to the formal system of the people. The view of ethnomathematics (Ascher &

D"Ambrosio, 1994) as cited by (Nursyahidah, Saputro, & Rubowo, 2018a) sees Ethnomathematics in investigating secondary school problem-solving strategies as

> *a mathematics that grows and develops in a particular culture which is perceived as a lens to view and understand mathematics as a cultural product. The culture refers to the language of society, place, tradition, and way of organizing, interpreting, conceptualizing, and giving meaning to the physical and social world* (Ascher, 1991, p. 87).

> *While ethnomathematics is mathematics which is applied to identify cultural groups such as tribal society, labor groups, children of certain age groups, and professional class, so, ethnomathematics is mathematics that arises from human activities in the environment that are influenced by culture (Nursyahidah, Saputro, & Rubowo, 2018, p.139).*

The conventional school mathematics structure is entirely different from what ethnomathematics addresses but gives insight to what the formal one is structured. The ethnomathematics is defined to be the tool or "lens" that helps to identify cultural groups, tribal society, ethnic-geographical settings belief to have a system and structure of formal mathematical patterns. This ethnomathematics can arise from human activities in the socio-cultural environment, tools, material artifacts used in cooking, drilling, playing games, farming, agricultural purposes, trading keeping records and to mention a few.

Ethnomathematics can be synthesized to denote a historiographical connotation. It is seen as a form of mathematics done by non-mathematicians who are ordinary or universal people from ethnic groups or tribal communities. The trend to which mathematics is transmitted through the history of knowledge dissemination is what is termed as "the politics of (ethno) mathematics education (Oliveras, 2000). The cultural dynamics of the encounters tries to figure out the mathematical conceptual framework of which it has progressively evolved to be like this current trend.

Rosa (2016) define ethnomathematics as a program of studies relating to the cultural aspects of mathematics. Every individual is surrounded by cultural imprints one way or the other. Making sense of mathematics out of culture brings meaningful and exploratory learning grounded on the bases of what we know already on the bases on what culture has taught us.

The meaning of the "*ethno*" concept is extended throughout its evolution (D"Ambrosio, 2001). It has been viewed as an ethnical group, a national group, a racial group, a professional group, a group with a philosophical or ideological basis, a socio-cultural group and a group that is based on gender or sexual identity (Powell, 2002; Michalowicz, 1997). The connection between cultural diversity and subject-based concept teaching is has been explored (Orey & Rosa, 2016; Rosa, Shirley, Gavarrete, & Alangui, 2017). A focus on making a connection to the curriculum adaptation has little concern. However, culture has now informed educators on the need to consider cultural diversities in designing teaching methodologies.

Ethnomathematics is seen by researchers in different allusions best seen by them. Concerning the field of mathematics, and in line with (Bishop, 2002) "consideration on mathematics as human and cultural knowledge, there appears to be a change in the meaning of ethnomathematics as diversity within mathematics and within mathematical practices (Rosa et al., 2016). This view of ethnomathematics permits us to see the liberal ethos educations concerning mathematics that describe the different mathematical practices, not only as revealing the diversity of mathematical practices but also to emphasize the complexity of each system. Thus, ethnomathematics is seen to describe the different mathematical practices that have its base concerning cultural diversity.

Karki (2017, p. 56) defines Ethnography "the scientific description of different races and cultures. It is a non-manipulative study of the cultural characteristics of a particular ethnic group. In another words, the researcher does not attempt to control of manipulative the phenomena under investigation, in an ethnographic study." Ethnographic research is in depth study carried out in a natural setting. The different conceptions of truth, reality and evidence held by some language researchers is one reason for the growing attention being paid to the ethnographic techniques for gathering and analyzing language data. When such study is linked towards understanding mathematical concepts form informal settings to the most formal settings, then ethnomathematics crop out. Hence, ethnomathematics is rooted from cultural diversity as summarized by (Orey & Rosa, 2016).

2.1.1 Origin of ethnomathematics

Many ethnomathematicians today started as teachers who became enthusiastic to find cultural connections to their pedagogical work. Among the pioneering work done by D"Ambrasio (1985). D"Ambrosio„s lecture at the International Congress on Mathematics Education (ICME 3) where he recounted his trajectory moments in ethnomathematics. Although many among the Congress raised concern about the allusions postulated by D"Ambrosio, the truth of the matter surrounding this contentious move underpins a correct postulate for this new era of mathematics education. The program of the ICME 3 was organized through survey papers that reported the perceptions of mathematics educators around the world on crucial issues. D"Ambrosio ideas raised an alarming concern for all mathematicians who are relatively informed by the dictates of culture from school and the community by which pedagogies are sharpened (D"Ambrosio, 1985; D"Ambrosio, 2016).

As attested by (François, 2009), ethnomathematics which is now applied in education had a Brazilian origin (indirectly referring to the pioneering work of D"Ambrosio). The brand of this form of mathematics has eventually become standard practice all over the world. It is evident that ethnomathematics has been extended from an exotic interpretation to a way of intercultural learning that is applicable within any learning context. Dealing with cultural diversity in the classroom is the universal context within which each specific context has its place informing what needs to be done in developing pedagogies (Fran & Kerkhove, 2010).

Ethnomathematics has now become philosophical stand-in mathematics. It gained fame in the opening speech by Brazilian educator Ubiratan D"Ambrosio at the 1984 Fifth International Congress on Mathematics Education in Adelaide, Australia, in order to popularize the relations between mathematics, culture, and society. This program has brought together mathematicians and mathematics educators who have different motivations for their pursuit of ethnomathematics under several international organizations such as the International Study Group on Ethnomathematics (ISGEm) and the Ethnomathematics Working Group of the International Conference on Mathematics Education (ICME). Since 1984, five international conferences on ethnomathematics (ICE) have been held in several places. Among such areas held include Spain in 1998, Brazil in 2002, New Zealand in 2006, the United States held in 2010, and recently held in Mozambique in 2014. These conferences have attracted ethnomathematicians and educators from many countries, illustrating the growing geographical scope of ethnomathematics. Since ethnomathematical concepts evolved from Brazil (Alangui, 2017; Alanguin & Rosa, 2010) recounts that it remains the leading country"s concern regarding ethnomathematical activity and has held four national congresses on ethnomathematics. Africa also is believed to possess much cultural diversity which makes it rich in breeding the high growth of ethnomathematical study. Ghana, for example, has rich cultural diversity dispersed among over 52 tribes with a common convergence of cultural imprints speaking aloud ethnomathematics education by integrating both informal and formal educational systems.

Numerous articles, book chapters, dissertations, and books were written about the relationship between culture, mathematics, and mathematics education (D‟Ambrosio 2001; Rosa et al., 2009; Favilli, 2000). During these decades, studies involving ethnomathematics were discussed and debated in a succession of local, regional, national, and international meetings, seminars, conferences, and congresses, (Alangui, & Rosa, 2010). These congresses and conferences show that mathematics education research in the field of ethnomathematics has been both active and evolving in many parts of the world. Also, they also show a variety of approaches that serve the bases and guidelines to the pedagogical and content structure in curriculum adjustment (Alangui et al., 2010).

According to (Shirley & Palhares, 2016), before the conception of ethnomathematics emerging from its field of study, mathematics teachers were looking up to culture to find examples to use in classroom teaching of mathematical concepts. Students find it comfortable when issues relating to their environment are referred to in the teaching and learning encounter. In the designing of mathematics textbook to conform to curriculum implementations, (Mills & Mereku, 2016) asset that, the textbook has been the main of references used by teachers in exploring the teaching of mathematical concepts. These textbooks make references to names of people used in the contest of mathematics problem solving where native names are used in the Ghanaian system.

The shifted meaning of ethnomathematics into a broader concept of cultural diversity became meaningful within the community of researchers working on the topic of ethnomathematics, multicultural education and cultural diversity. Where the topic was absent at the first two conferences of the Conference of European Research in Mathematics Education (CERME 1, 1998; CERME 2, 2001), the topic appeared at CERME 3 (2003) as *Teaching and learning mathematics in multicultural classrooms*. At CERME 4 (2005) and CERME 5 (2007), the working group was called *Mathematics education in multicultural settings*. At CERME 6 (2009) the working group was called *Cultural diversity and mathematics education* (Gerdes, 2001).

The current trend of ethnomathematics is poised to enrich pedagogical skills and curriculum focus. From now on, there is an explicit consideration of the notion of cultural diversity (Orey et al. 2016). Culture is diverse by nature, and its contribution to scientific interpretations is the concern. No wonder D‟Ambrosio stated categorically in his overview comment on the history of ethnomathematics as "the present is the interface between past and future" (D‟Ambrisio, 2016, p. 23). Today‟s mathematics education depends so much on what the past holds by initiators of mathematical concepts taught in today‟s classroom. In the same manner, the future of the subject is also dependent on what the present decision for the future trend of mathematics education.

Several elements in Mathematics Education in Ghana has also been significantly surveyed by mathematics educators on the structure system of the curriculum (Dennis et al., 2018) and the methods many Ghanaian teachers use in teaching. For example, it was observed that "both the official curriculum and the teachers, who implement it, emphasized expository teaching methods" in the teaching and learning of mathematics. A look into how past and present can help project the future of mathematics

(D"Ambrosio, 2016) in a clearer merge of ethnomathematics into the formal system must be of a try for all.

2.1.2 Proponents of Ethnomathematics

Ethnomathematics have been advocated by several authors whose contributions have brought into the light, the existence of cultural interplay into mathematics philosophies. To some extent many mathematics educators who resource to mathematics teaching of concepts to induced meaningful learning are themselves ethnomathematicians (Imswatama & Lukman, 2018)

This philosophical idea originated from Brazilian mathematics educators D"Ambrosio in the late 1976s. Ethnomathematics as a research program got attention to be seen as a philosophy of mathematics with the pedagogical implication in 1985. It was during the Annual Meeting of the National Council of Teachers of Mathematics held in USA where International Study group on Ethnomathematics (ISGE) was founded (D"Ambrosio, 2004). His vision into this raised the concern of many interests into this field (Rosa et al. 2001; Rosa et al. 2016)

The initiator's definition of Ethnomathematics uses the etymology of three Greek roots, *ethno*, *mathema*, and *tics*. It was seen that there is "a program that incorporates mathematical ideas and procedures practiced by the members of distinct cultural groups, which are identified not only as indigenous societies but as groups of workers, professional classes, and groups of children of a certain age group as well" (D"Ambrosio 1985). D"Ambrosio recounts in (Rosa et al., 2016) overview of the history of ethnomathematics in the following:

> My first participation in an International Congress on Mathematical Education was in the 1976 ICME 3, in Karlsruhe, Germany. I consider the ICME 3 a milestone in Mathematics Education. Many mathematics educators at the Congress raised

> concerns about issues that were beyond mere content. Many proposals for study groups, among which were the History and Pedagogy of Mathematics (HPM), Political Dimensions of Mathematics Education (PMDE), and the Psychology of Mathematics Education (PME), were launched at the ICME 3. Pg. 137

Several authors shared a common idea towards their conviction of what ethnomathematics was about. In the bid to explain further, the meanings to ethnomathematics (Budiarto et al., 2019a) see culture in the contest of learning situation and defines "Culture or context" as a set of attitudes and thoughts with their one logic but that a given situation can bring together to the heart of the same phenomenon".

Some ethnomathematicians look at language component of culture. Others looked at ethnomathematics regarding language factor in the teaching of mathematics (Clarkson, 2006; Rudd, Lambert & Satterwhite, 2009). Language form the bases of communicating mathematical concepts from the teacher to the students and vice versa. The use of classroom mediated language in teaching mathematics has been analyzed to be one of the most influential elements in teaching strategies (Cycleback, 2014) especially when teaching number literacy. Ghana, for example, has about 52 languages entirely different from each other and communities for which the language is used as a medium of communication. This language, however, is bound by Ghana Education (GES) language policy emphasizing the use of local language in teaching the curriculum content in the lower primary. Orton (1987) had a language based ethnomathematical idea:

> It might be that problems of vocabulary are considered to be fairly superficial within the whole issue of language and mathematics learning, but it is nevertheless critical that such problems are not ignored in the hope they will go away, (Orton 1987 p. 427

Jill Adler share a similar "language of teaching dilemmas," a conviction on ethnomathematics in unlocking the complex multilingual language system in the teaching of mathematics

Many pioneering mathematics education philosophies such as Bishop (1988, 1990, p. 14) investigated into the "Western Mathematics" by emphasizing on implicitly on ethnomathematics as "the Secret Weapon of Cultural Imperialism."

Ethnomathematics is currently helping mathematics educators in exercising various teaching pedagogies (Shirley & Palhares, 2016). Teachers used of ethnomathematics have diverse pedagogical and methodological implications. Shirley et al. (2016) counted on ethnomathematics and its diverse pedagogical approaches and cited Zaslavsky (1998) classic early case of a school teacher who turned out to be ethnomathematicians through various interactive teaching programs. Teachers used of culturally adapted mannerism best known to the community in which the learner is found could, for example, have implicative meaningful learning inducement. The use of gesture for counting among Tanzania *Mankala* games and other local applications of mathematics was seen by Shirley et al. (2016) as enhancing peoples understanding of mathematical learning on number systems and operational algorithms. Similarly, most of Ghanaians communities" way of counting numbers use the hand, fingers, tallies, stripping games and among others to bring their mathematical knowledge into the light. They are the need to find out whether these culturally adapted attitudes of selected Ghanaian tribes have mathematics education implications from the informal position to the formal one.

Several other parts of African communities possess more examples of mathematics portrayed in African culture. In her book Africa Counts (Zavlavsky, 1998) elaborated on African cultures in different forms, which became a favorite resource for teachers in the United States, Africa and elsewhere as confirmed by Shirley and Palhares (2016).

According to (Fitroh & Himawati, 2019), education and culture is something that cannot be avoided in daily life because culture is a unity which is applied in society. One of the measures to bridge the gap between culture and education is the infusion of ethnomathematics into the curriculum structure of the people (Massarwe, Verner, & Bshouty, 2010; Verner, 2013). According to Fitroh and Himawati (2015), ethnomathematics is mathematics, which had an influence or is based on culture. So far as we need mathematics teaching, we must be resourceful enough use materials based on ethnomathematics that relates mathematics to real condition and culture in society. Mathematics teaching material are very useful in helping students understand mathematical concepts (Alangui, 2017; Lena, Netriwati, & Suryanita, 2019; Wijayanti et al., 2019), mathematics educators can relates mathematics material with culture. It is expected, this would be able to train leaner in solving mathematical problem and help develop mathematical critical thinking skill (Imswatama & Lukman, 2018).

Existing literature on mathematical modeling guided through various mathematical philosophies has been confronted under the new era and emergence of ethnomathematics. Such an "elitist view has been challenged by researchers for whom epistemological and ontological perspectives on learning are grounded in ethnomathematics, building a case for listening to the voices of the oppressed in designing instruction" (Rosa & Orey, 2016, p. 44) as cited by (Bean-folkes & Ellison, 2018; Lewis, Manouchehri & Gorsuch, 2017)

2.2 Theoretical Review (Frame Work)

The search of knowledge continues to revolve around complete evolution so as to put the best on the table of education. Ethnomathematics is naturalistic philosophy, somewhat considered to be a program of continuous evolution. At the commencement of its history traced to the pioneering work of authors of ethnomathematics (Borba, 1990; D"Ambrosio, 1985; Kitto, 1990; Pinxten, 1994; Zaslavsky, 1994), Ethnomathematics had the purpose of recognizing ideas and practices of different cultural groups but it subsequently evolved to embrace wider studies centered on the ways in which cultural and social context affects the process of generation, organization and communication of knowledge. Ethnomathematics theory draws our attention to the fact that;

> "mathematics with its techniques and truths, is a cultural product and that every culture and sub-culture has its sense of mathematical development that make them unique" (D"Ambrosio, 1985, p. 45)

It is upon this base that indigenous technology and civilization evolves (Sudirman et al., 2020) which undoubtedly advances to higher level learning from informal perspective to the most formal connections (Gerdes, 1994). According to (Cimen, 2014), "a culture shall not take the perspective of rejecting the evolution of mathematics; but rather align their respective culture and develop learning". The culture of the people shows much concern in solving the most prominent societal problems.

Ethnomathematics study rubbishes the overriding Eurocentric approach to teaching mathematics ideas (Bishop, 1997). The notion that mathematics is a subject with its content originated from Western lands to native Africans. A critical look at every culture is the idealization of mathematical concepts guarding their indigenous technologies. Mathematics become whitish in the lands of Africans and enslave them somewhat to disown cultural heritage. Culture has a lot to speak when it comes to conceptualization of ideas. It is through its precepts that we can organize mathematics lesson into resource-based teaching, pedagogical moves in teaching and facilitate meaningful learning of mathematics problem-based learning (Hadayati & Restapaty, 2019).

The research arena of ethnomathematics contributes to the broader theoretical base where cultural diversity is deeming to influence teaching and learning of mathematical concepts (Rosa et al., 2016). "The arts or techniques developed by different cultures to explain, to understand and to cope with their environment" (D‟Ambrosio, 1992, p. 184) as cited in, (Naresh, 2015). Ethnomathematical studies could be sketchily classified into the following components:

1. Those that challenge the traditionally told euro-centric history of mathematics (e.g. (Bishop, 1997; Frankenstein & Powell, 1997; Gerdes, 1997; Kitchen & Becker, 1998; Michalowicz, 1997; Naresh, 2015)
2. Ethnomathematics of the people belonging to indigenous and little known cultures of the world e.g. (Ambrosio & Gerdes, 1994; Ascher, 1991)
3. Ethnomathematics of social groups in everyday settings e.g., (François, 2016; Ismail & Ismail, 2010; Miller, 2019).
4. ethnomathematics and its connections to mainstream academic mathematics (e.g., (D‟Ambrosio, 1997a; Greene, 2000; Greer, 1996) and
5. socio-cultural-political influences on the development and evolution of ethnomathematics e.g., (Bishop, 1997; Frank, 1997, Vyskosky, 1834).
6. African Mathematics Educators‟ observation on western science alone unable to address all the needs of Africans (Davis & Seah, 2016; Mereku, 2013; Nabie, 2015; Okpoti, 2001; Zavlavsky, 1998) and that our culture must be considered when teaching formal curriculum standards.

Mathematics educators needs to (Mukhopadhyay, 2009), enlarge the scope of ethnomathematics to include the conventional theoretical mathematics and school mathematics. From this viewpoint "ethnomathematics is not proposed, as is often believed, as an alternative to either academic mathematics or school mathematics" but could co-exist and thrive within the realms of academia (p. 70) and this approach inspired the ideas discussed in this thesis.

Ethnomathematics study claptraps the overriding Eurocentric approach to teaching mathematics ideas. It holds the belief that when mathematics is taught to draw closer to the child; his own environment and culture, there is a significant association between the content studied and the construct learn (Bishop, 1998). Again, ethnomathematics holds the belief that when mathematics is taught to draw closer to the child; his own environment and culture, there is a significant association between the content studied and the construct learn (Bishop, 1995). Students understanding of mathematics problem solving abilities rely hugely on how best they can image associated things from their environment. Studies on the problem-based learning model by (Patmara et al., 2020) with mathematical nuances was tested to be effectively increased the average problem-solving ability of students to reach 75% standard completeness with mathematics problem solving.

In discussing the early writings of mathematics and it connection to ethnomathematics (Barton, 1996) reviews anthropological writings about the mathematics of other cultures which did not discuss the links between mathematics and culture. For example the work of (Abraham & Bibby, 1988; Ascher & D"Ambrosio, 1994; Zaslavsky, 1973) were all supportive in bringing into light, what (D"Ambrosio, 1985) conceded for ethnomathematics approval in mathematics conference. Such writing is part of the genre which has come to be encompassed by the term 'ethnomathematics for many mathematics educators are exploring in research.

The nature of mathematics has been deliberated from at least Greek times. Many authors have either stated, or implied that, mathematics is a cultural phenomenon. Others also hold to mathematics been naturalistic, formal and intuitionist based. Mathematics philosophy irrespective of the brain behind its postulate has its development been culturally dependent. The idea that mathematics has an artistic or sociological or cultural heritage was often expressed. Gerdes (1993) mentions the relevance of looking into the future of mathematics education by appreciating resourceful base of mathematics teaching with ethnomathematics.

Two views of Ethnomathematics that respond to this evolution, according to (Albanese et al., 2017) are mathematics as cultural practices and ethnomathematics as different ways of thinking. The first view implies recognizing mathematics in the practices of cultural groups, and this research is performing in accordance to the categories and schemes of thinking of the researcher‟s and respondent‟s culture. The second view implies discovering different ways of knowing measurements, quantity, space and relations as well as other mathematical conceptual framework (Peni, 2019). Considering a broader concept of ethnomathematics where the categories and schemes of thinking of the studied cultural group are taken into consideration. The idea of mathematics in cultural practices involves designing tasks that are contextualized in the cultural heritage. On the other hand, the idea of a different way of knowing can help to reflect on certain mathematical notions or on the nature of mathematical knowledge (Albanese et al., 2017; Barton, 1996).

In an ethnomathematics-based program there exists the need for teachers to identify pedagogical actions in the form of teaching-learning practices (Rosa & Orey, 2016). The need to investigate from Ghanaian perspective, an ethnomathematics and a linkage to curriculum proposal based on D‟Ambrosio‟s Trivium and what other scorers who share D‟Ambrosio‟s view which have been surveyed from other part of the world.

2.2.1. Ethnomathematics Trivium Theory

Ethnomath modelling suggest a curriculum-based that focuses on the trend by which ethnomathematics could be adopted into the mathematics curriculum and its implementation. The Trivium is a three-tier ethnomath model that suggest how the mathematics could be taught in an altitude that would bring the learning into literacy knowledge, acquire mathematical skills and be aware of technology in the current trend of teaching mathematics. The Trivium curriculum is composed of *literacy, matheracy, and technoracy* that allows for the development of school-based activities and pedagogies of teaching mathematics on an ethnomathematics foundation. The Trivium supports the development of school activities based on a foundation of ethnomathematics and modelling. In this trivium curriculum implementation , *literacy* is the capacity students have to process information present in their daily lives; *matheracy* is the capacity students have to interpret and analyze signs and codes in order to propose models and to find solutions for problems faced daily; and *technoracy* is the capacity students have to both use and combine different instruments in order to help them to solve problems (Rosa & Orey, 2015). This study would refer to this trivium as LMT. In LMT, Numeracy plays an important role in this curriculum implementation that best fit pedagogical actions adopted from cultural perspective.

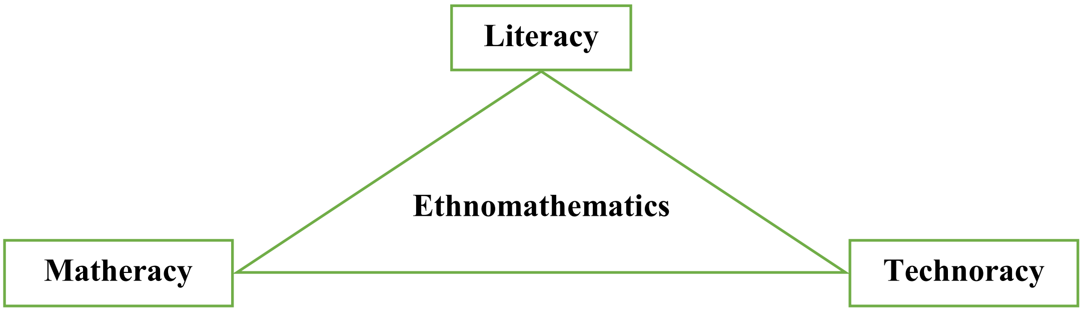


Figure 2.1: The ethnomathematics trivium

Mathematics education is perceived by most students as difficult and develop some negative attitude towards its study (Orim & Uzoma, 2019). It is commonly known that many people have negative attitudes and emotions toward mathematics. For some people the negative emotions toward mathematics may evoke severe anxiety, and as a consequence, these people often avoid mathematical activities (Alkhudair, 2019; Ndiaye, 2019; Nugroho & Widjajanti, 2019).The literacy of mathematical concepts depends so much on the mathematical cognitions of constructs and concepts. It is this that forms the bases of matheracy. The fulfilment of this is facilitated by the current demand of technology in the teaching and learning of mathematical concepts. The technological bases of teaching mathematics together with indigenous resources that facilitate teaching and learning of mathematics is seen by (Rosa and Gravarrete, 2016) as technoracy. We discuss in the subsequent sub-sections the trivium theory of ethnomathematics.

In order to respect cultural dignity as well as prepare students fit well in the society it is necessary to learn more than what is offered in traditional mathematics curricula. Hence a blend of formal and informal mathematics in the context of Ghanaian societies should be considered. Mathematics education should give students the profound chance to both critically and reflexively use communicative instruments. They are to apply a diversity of analytical instruments adopted from culture to facilitate the learning of mathematics. Again, students must have the opportunity to become aware of the capability and inadequacy of the use of technological instruments that are essential to exercise rights and duties necessary to appreciate dynamics of cultural heritage. Ethnomathematics fits this broad view of education because it is conceptualized as a research program based on epistemologies and histories that focus on science and mathematics. Undeniably it has significant implications for developing pedagogical actions that may occur in mathematics classrooms for the implementation of mathematics curriculum, (D"Ambrosio, 2001; Mesquita, 2017)

Ethnomathematics helps in the development of *numeracy* that focused not only on basic mathematics but all aspect of mathematical concepts most especially geometry, (Kitto, 1990; Maryati & Prahmana, 2019; Muhammad et al., 2019). The development of these mathematical skills is not limited to the ability to count, calculate, and master a number of common algorithms but also reconcile cultural identity to mathematical constructs. This would help the Ghanaian child appreciate what they have and help meet the national goal prescribed the teaching syllabus (GES, 2010). Thus, it has become a need to look into a new role for teaching numeracy through ethnomathematics pedagogical moves. It has become necessary in response to increasingly relevant sociocultural demands of a contemporary society which has multicultural systems like Ghana to consider ethnomathematics pedagogical strategies in teaching. An expanding body of international literature has shown distinct viewpoints in numeracy, which reveals a number of diverse ways that this approach is defined around the world. Regarding the development of the concept of numeracy, a wide variety of related terms are currently in use, most notably: *mathematical literacy, quantitative literacy* and *matheracy*. For example, when referring to the competency of applying mathematical knowledge to understand and solve real world problems and phenomena; Australia and the United Kingdom generally apply the term numeracy while the United States applies the term quantitative literacy. These are not different from what Ghanaians see mathematics numeracy to be. Many Ghanaians belief mathematics numeracy conforms to computation easiness or difficulties, (Seah et al., 2015).

This approach also suggests that these concepts may have similar meanings in the many international contexts from which they have emerged. For example, in "Australia, educators and policy makers have embraced a broad interpretation of numeracy similar to the OECD definition of mathematical literacy" (Goossens, 2019, p.12). In the Australian context, individuals are numerated when they develop competencies to use mathematics to solve practical problems in their daily lives, and use mathematics as tools for learning mathematics in other contexts. Thus, numerated individuals are able to "use mathematics effectively to meet the general demands of life at home, in paid work, and for participation in community and civic life" or perhaps get enrolled in university admissions. (Australian Association of Mathematics Teachers-AAMT, 1997, p. 15). In Ghana, students" performance in mathematics is to jump over the huddle of WASCE so as to get admissions into universities.

The essence of an ethnomathematics program is to bring awareness to the many different ways of *knowing and doing* mathematics that relate to ideas, procedures, and practices contextualized in the strands of *literacy*, *matheracy*, and *technoracy*, which are the components of the *Trivium* concept for a mathematics curriculum. Therefore, it is important to consider the appropriation of academic mathematical knowledge in different societal sectors in order to help members of distinct cultural groups to negotiate their own mathematical practices (D"Ambrosio, 1999b). Ethnomathematics is related to the development of students" competencies, abilities, and skills through the study of mathematical ideas, procedures, and practices directly connected to their own sociocultural context. In this regard, matheracy allows students to develop local, logical, and mathematical reasoning abilities in a variety of environments. It also supports the capacity to use mathematical knowledge to solve real world problems by applying number sense and numerical operations, interpreting statistical information, and developing new forms of information in various mathematical concepts such as geometry, number and numeration, probability and statistics, mensuration and among others (Cahyono & Dwidayanti, 2019; Himmah et al., 2019; Interactive Stem, 2015; Narulita et al., 2019; Purwanti & Waluya, 2019; Purwanto, 2019)

From this perspective, numeracy is not limited to the study of traditional academic mathematical and geometric concepts because it is related to critical applications of mathematical knowledge and procedures through the use of numerical, statistical, probabilistic, and measurement tools to solve situations by linking these competencies to citizenship in modern society (D"Ambrosio 2001). In this regard, the concept of matheracy encompasses these numeracy outcomes. This perspective emphasizes the importance of the community in relation to the school environment by making direct connections between academic school mathematics to the mathematical cultural practices developed, practiced, and used locally.

Literacy:

Literacy is the capacity students have to process information present in their daily lives. Sociocultural approaches to formal and informal knowledge transmission demands a high literacy composition. This when considered in the mathematics curriculum would combat curricular decontextualization bring about a monocultural view (Rosa & Gavarrete, 2017). This pedagogical action can be achieved by the application of innovative approaches to ethnomathematics such as the trivium curriculum and ethnomodelling, which need more investigations to address the pedagogical purposes of the ethnomathematics program: , (Rosa, Shirley, Gavarrete, & Wilfredo, 2017).

As it helps them to understand their role in solving everyday problems. This approach is known as quantitative literacy, which is defined as the ability to understand and use numbers, and to analyse data in everyday life. This concept also deals with "mathematical content knowledge, mathematical reasoning, understanding of the social impact and utility of mathematics, understanding the nature and historical development of mathematics, and mathematics disposition" (Wilkinson & Shank, 2019, p. 112). These concepts are developed according to often unique and very distinctive theoretical, social, and historical foundations across cultures. This have come to influence the decision-making process as developed by its members. This development is important because differences in political and cultural traditions create significant differences in both the objectives and outcomes of mathematics education (Knijnik, 2002). It is therefore necessary to investigate a variety of perspectives that come from diverse sociocultural contexts that vary with the values and rationale of the specific stakeholders influencing mathematics education. These perspectives tend to be diverse and dynamic, and present us with ideas and questions relating to how mathematical skills and concepts should be applied in critical and reflective ways. This approach assists us in examining our social, cultural, economic, political, and environmental surroundings in order to push students and communities for social change as we help them explore and appreciate teaching and learning from ethnomathematics base (Zidny & Eilks, 2018; Enukona, 2002).

Literacy is used as a means of communicative instruments in teaching and learning. Literacy is the ability to process information by applying techniques of reading, writing, representing, and calculating in a variety of diverse media contexts. It can be understood as the competencies related to the processing and creation of information, which include abilities such as checking prices, times, schedules, using the units of measurement, performing mathematical operations, as well as numeracy competencies such as interpreting graphs and tables (D"Ambrosio 2013). It is a process that allows individuals to successfully manage daily routines and gain access to information. From an ethnomathematics perspective, literacy is best understood as the integration of school and cultural contexts through the process of cultural dynamism. This approach allows students to exchange academic knowledge with the school community by processing information from their own cultural context (Ros & Orey 2006). For example, in regard to pedagogical practices, curriculum activities related to social studies would begin with the history and context of students" immediate family and community with the objective of searching for their sociocultural identification (D"Ambrosio, 2008). In the same manner, teaching mathematics should address the need to consider the child"s immediate environment where mathematics could be explored and applied. The same concept can be applied in relation to the mathematics curriculum in which teachers may begin with the cultural context of their students in order to explore local mathematical ideas, procedures, and practices with the objective to empower them and create context for the ongoing learning of mathematics.

From the perspective of mathematical modelling through these trivia, teachers guide students to select topics through brainstorms, dialogues, and discussions. Themes can be very general in nature, allowing students to explore mathematics creatively, or adhering to the existing curriculum designed to be studied (Wedege, 2010).

The implementation of mathematical modelling is done through mathematics literacy and must be preceded by an ethnographic investigation of mathematical ideas and procedures, and practices of sociocultural systems that are part of the school community. This may be connected to various learning objectives found in schools (Aleksić, Merrell, Ferring, & Tymms, 2019; Ferreira & Fonseca, 2017). Teachers" encouragement is important in helping students in the choice of a broad theme that is both motivating and valuable to the school community. However, this approach only functions well if students are able to communicate properly in a diversity of ways, using spoken and written language, signs, gestures, numbers, as well as visualization (D"Ambrosio, 2013).

Matheracy

Matheracy is the capacity students have to interpret and analyze signs and codes in order to propose models to find solutions for problems faced daily. Matheracy is considered to be the use of analytical instruments in manipulating mathematical concepts to the maximum understanding. Matheracy can be understood as the capability to interpret and manage signs and codes as well as the ability to both propose and use models in everyday life. It helps students to develop statistical competencies which include the abilities to collect, read, understand, propose hypothesis, infer, and produce and interpret data to assess their validity in order to draw conclusions. Matheracy provides students with symbolic and analytical instruments that help them to develop their creativity and enable them to critically understand and solve problems and situations (D"Ambrosio 2013).

From another point of view, matheracy focuses on deep and critical reflections on the role that mathematics plays in society. In this perspective, matheracy does not refer only to the meaning of mathematical abilities, but also to the competencies needed to interpret and act in social, cultural, political, and economic situations structured by mathematics (Skovsmose & Vithal, 1997; Skovsmose 2005). This means that the concept of matheracy is broader than basic mathematical skills because it includes the concept of numeracy and literacy as it enables the development of more complex abilities of mathematical reasoning (D‟Ambrosio 1999).

From an ethnomathematical perspective, matheracy can be described as the domain of skills, strategies, and competencies that empower students to be mindful of the way in which members of distinct cultural groups explain their beliefs, traditions, myths, symbols, and scientific and mathematical knowledge. Representations given by these elements enable the expansion of mathematical simulations and models by incorporating in this process both mentifacts and artifacts (D‟Ambrosio, 1999). D‟Ambrosio refers to Mentifacts as the shared ideas, values, and beliefs such as religion, language, mathematics, science, viewpoints, law, and knowledge developed and diffused by members of distinct cultural groups from generation to generation. Artifacts are the cultural objects and technological tools created by members of distinct cultural groups. These artifacts comprise the technological subsystems composed of material objects and the techniques developed for their use.

In the context of mathematical modelling as a pedagogical action of ethnomathematics programs, matheracy is the capacity to interpret, manipulate and handle symbols and codes in order to elaborate and use models in everyday life (Barbosa, 1993; Barbosa 2006). This approach is an essential element in the decision-making process in the preparation of a plan towards the elaboration of mathematical models. This process allows students to interact with the world so that they are able to understand and find solutions to problems faced daily through the elaboration of models that represent systems taken from reality. An essential procedure to the comprehension of phenomena is the analysis of the relations between variables by applying known and unknown mathematical content (Rosa & Orey 2010). It is important to highlight the importance of teaching academic mathematics content in conjunction with the process of learning mathematics in contexts. However, if the solution to these models requires the use of mathematical techniques and strategies that are not available to students (Ferreira & Fonseca, 2017; Ferreira & Fonseca 2017), there is a need for teachers to act as mediators in this process by equipping students with the necessary mathematical strategies and technological tools to assist them in the elaboration of models and mathematical computations, (Rosa & Orey 2007).

This means that matheracy can be used as an instrument to develop political actions that consider the relationships between mathematics, cultural environment, society, and curricula, which are actions that focus on the development of an informed citizenry (D"Ambrosio 1998). Thus, it becomes necessary to use mathematical models to make forecasts and analyses, to formulate actions in reality, and to propose action plans for the cultural curricula reformulated by the school community, and the nation at large, (Rosa & Orey 2010). In this direction, a mathematics curriculum may be considered as the formal basis by which students become mindful of diversity in the context of real-world models, which are rooted in concrete situations and problems that occur throughout history. In this approach, matheracy allows for an understanding of facts and phenomena that focus on deep reflections about society (D"Ambrosio & D"Ambrosio 2013) through the elaboration of cultural models in mathematics.

From an ethnomathematical perspective, the development of numeracy is also embedded in matheracy which allows individuals to mobilize knowledge associated with processes of quantification, ordination, classification, modelling, and orientation. It also allows individuals to interrelate, operate, and represent knowledge that is necessary to solve problems faced on a daily basis (D"Ambrosio 2001). This concept facilitates the use of mathematical knowledge that makes the development of transformatory actions based on the individuals‟ critical reflection possible. Thus, the understanding of social and political contexts contributes to the comprehension of relations between mathematical knowledge and society. This understanding enables students to emancipate themselves socioculturally and to participate in acts of social transformation. This will help improve the conditions of their communities (D‟Ambrosio & D‟Ambrosio 2013) through a process of progressive mastery of numeracy abilities.

Technoracy

Technoracy is the capacity students have to use and combine different instruments in order to help them to solve these problems (Rosa & Orey 2016). In the ethnomodelling approach, the use of ethnomathematics assumptions and the application of tools and techniques of mathematical modelling allow us to perceive reality by using different lenses, which gives us insight into mathematics performed in a holistic way. We look at technology beyond highly sophisticated computers and engine and chip-based computers. Technology could be lowered to cultural adaptations created indigenously. Technoracy is connected to Ethnomodelling. Ethnomodelling is a research paradigm related to critical-reflective dimensions of learning that allows learners the opportunity to develop a sense of purpose and their own potential by using mathematics to examine and solve problems they themselves choose and deem important (Rosa & Orey 2016).

Pedagogical approach adopted for teaching mathematics in the context of ethnomathematics demand demands resourceful teaching using different instruments termed tehnoracy. It is not often reflected in the traditional mathematics classroom, yet high equitable expectations along with personalized connections in mathematics instruction are essential for success for all students. In this way, the pedagogical innovation proposals raised from the ethnomathematics program can encompass the incorporation of sociocultural components. Ethnomathematics in technoracy envisions mathematics as a human activity in all cultures as well as a social phenomenon, thus, contributing to a functional vision of helping students understand mathematical concepts in a modern trend (Furuto, 2014). The strategies of ethnomathematics and culturally responsive pedagogy are grounded in scientific research and three primary theoretical approaches: respecting and understanding social and cultural capital, engaging effective models of professional development and incorporating values-based education.

Ethnomathematics uniquely unites a broad cluster of ideas ranging from distinct numerical and mathematical systems with identity, including race/ethnicity, socioeconomic class and special needs (D"Ambrosio, 2001). D"Ambrosio explains that it is generally not common to connect mathematics and identity. When a link is acknowledged, it is often a brief multicultural activity removed from the students in the class. First, an important component of mathematics education should be to reaffirm the individuality of students through social and cultural capital. Educational research has shown a relationship between student success and an increased role for context in the curriculum; for example, „recognition of diverse knowledge systems, use of local funds of knowledge, and the value of community understandings through social and cultural capital show that indigenous student performance improves when cultural and linguistic practices are employed, (Peni, 2019).

Technoracy is also seen as the use of material instruments in the teaching of mathematical concepts. The increasing presence of technological instruments in all areas of life have led to a growing demand for higher-level cognitive skills that include numeracy abilities found in understanding, interpreting, analysing, and communicating information. It is necessary to integrate the use of technological tools such as computers, software, calculators, and digital equipment into the process of teaching and learning mathematics in order to enable students to mediate and shape their mathematical thinking and numeracy competencies (Clapp, 2017; Eglash, 1997; Imswatama & Setiadi, 2018.; Sharples et al., 2019).

Technoracy refers to people"s ability to critically use and combine different technological tools, from the simplest to the most complex, and their ability to evaluate possibilities and limitations in diverse everyday situations in order to make suitable decisions for themselves and for others. It also makes use of numeracy competencies, such as the understanding of the condensed language of codes and numbers, through the use of technology, such as calculators and computers (D"Ambrosio, 2007) and other technological resources. Thus, technoracy can be considered as the individuals" critical and reflexive familiarity with technology (Dalby & Swan, 2019). This familiarity allows them to use technological instruments in order to evaluate diverse ways to present and represent mathematical ideas and practices, and to assess the reasonableness of the results and their contextualization (Amador-Lankster & Monsalve, 2018; Zevenbergen, 2002). The gap between informal and formal mathematics education in especially Ghana is the knowledge of current trend of technology. Whether ever civilization technology has cause, there are always the bases of ethno-technology generated through indigenous perspective.

As contemporary societies are highly technological, the use of technological tools as material instruments has an important role: to help individuals to succeed in the world by solving new problems and situations. The importance of technological knowledge manifests itself in the need for students to be able to use technological tools available to determine the solution of various and diverse problems and situations proposed in the classrooms (Budiarto, Artiono, & Setianingsih, 2019). However, it is important that situations and problems used in mathematical classrooms in SHS are contextualized in order for students to use adapted strategies, including the applications of their artifacts and mentifacts, to solve real life problems.

From an ethnomathematical perspective, technoracy is considered as an important feature of scientific knowledge (mentifacts) and the reification as artefacts. In this context, technoracy can manifest itself in technological tools that translate ways of dealing with natural, social, cultural, political, and economic environments that facilitate the incorporation of diverse modes of explanations, beliefs, traditions, myths, and symbols (D"Ambrosio, 2008). Thus, an ethnomathematics program posits a political proposal embedded in ethics, and focuses on the recovery of cultural dignity of the members of distinct cultural groups. With the advancement of technology, mathematics develops the power to project reality by shaping the future. The benefits and possibilities in relation to the use of technologies are undeniable in order to increase the quality of life (D"Ambrosio, 2008). Frequently, the elaboration of mathematical models is developed according to mathematical and technological tools used in a specific sociocultural context (Rosa & Orey 2010). In this process, it is necessary for students to develop critical thinking skills by inviting them to reflect holistically on the consequences of inappropriate uses of mathematical and technological tools. For example, responsibility of errors must be admitted if students enter wrong mathematical algorithm for unintended wrong answer outputted by the calculator.

One of the most important ethnomathematics pedagogical strategies for developing technoracy is confirm students" solution form mathematics Problem-Based Learning (PBL) adopted from cultural settings using Realistic Mathematics Education (RME). In this regard, students are able to develop and elaborate mathematical models in order to use them to study and solve problems related to urban pollutions (residential and industrial waste) and environmental pollutions (air, water, soil, sound, and visual). It is also important that teachers prepare students to become future technology users and help students to develop a sense of mindfulness towards the use of technological products with the hopes that these products may be used for positive purposes (D"Ambrosio 2008).

2.2.2 Vygotsky Sociocultural Theory and its Implication to Ethnomathematics

Lev Vygotsky's sociocultural theory of development focuses on language, social and cultural influences on a child's developing mind. In this theory, children use cognitive tools to understand their surroundings and the world. Vygotsky's theory stated that culture along with social interaction and language all directly influenced one another as well as cognitive development. The work of *sociocultural theory* is to explain how individual mental functioning is related to cultural, institutional, and historical context. Vygotsky"s sociocultural theory of human learning describes learning as a social process and the origination of human intelligence in society or culture (Vygosky, 1978).

The major theme of Vygotsky"s theoretical framework is that social interaction and cultural exploration plays a fundamental role in the development of cognition; which in this case is bases of mathematics intuition of concept formation and understanding. Teachers can use ethnomathematical pedagogies as a tool (favourable condition) to assist children to complete learnable task more easily inside their „*zone of proximal development*". The work of *sociocultural theory* is to explain how individual mental functioning is related to cultural, institutional, and historical context. Vygotsky"s sociocultural theory of human learning describes learning as a social process and the origination of human intelligence in society or culture (Dennington, 2015; John-Steiner & Mahn, 1996; S. Scott & Palincsar, 2018; Vygosky, 1934).

The major theme of Vygotsky‟s theoretical framework is that social interaction and cultural exploration. This plays a fundamental role in the development of cognition; which in this case is bases of mathematics intuition of concept formation and understanding of cultural heritage of people, (Friansah & Yanto, 2020)

2.2.3 The constructivist view of Mathematics education

This research was also influenced by leading scholars in education reform such as psychologist (Vygotsky, 1978) and philosopher (Dewey, 1916). However, the main theory that forms the theoretical foundation of this research is "*Firsthand Learning Through Intent Participation*, (FLTIP)" (Rogoff, Paradise, Arauz, Correa-Cavez, & Angelillo, 2003, p. 98), which has similar components to the work by the aforementioned theorists. The schools of thought of both (Dewey, 1916) and (Vygotsky, 1978) support the constructivist view of education, which states that learning is socially constructed, in which the learner is the key actor (Ornstein & Hunkins, 2017). Cultural variables are themselves socially constructed and conforms to the constructivist theory on adaptive learning.

Dewey (1916), maintains that knowledge is formed when humans actively interact with their environment. Similarly, Vygotsky (1978) believes that a children‟s thoughts and actions evolve from interacting with their sociocultural background. Therefore, socializing fosters cognitive development with a „More Knowledgeable Other‟ (MKO) within their environment, which may include parents, teachers, or peers. The formation of these acquired skills negotiates further learning. Vygotsky (1978) described the zone where learning takes places as the Zone of Proximal Development (ZPD), the bridge that separates a student‟s ability to independently complete a task and his/her ability to complete the task with an MKO scaffold, (Dennington, 2015; John-Steiner & Mahn, 1996; S. Scott & Palincsar, 2018; Vygosky, 1978, 1998). Both theorists favour the pragmatist perspective of ethnomathematics education that view learning as what works.

Rogoff et al.‟s (2003) *learning through intent participation* theory examines the informal way children learn by intently listening in and observing, and then voluntarily participating in the communal activities based on expectation define by cultural interactions such as games and observing menifacts and artifacts. Rogoff et al. further explained that such learning is common among indigenous communities and charitable institutions depending on voluntary work, and in middle-class schools in U.S. communities, which foster learning by engagement in a shared task; each person is held accountable for the success of the other. Rogoff et al.‟s theory is rooted in (Dewey, 1916) naturalistic view of knowledge and share similarities with (Vygotsky, 1978) social developmental theory which is a natural embedment in culture.

Rogoff et al.‟s (2003) theory involves the learner participating in a particular task by interacting with a more experienced person which can be parallel with the MKO that scaffold learning in Vygotsky‟s theory. Rogoff et al‟s. theory of intent participation and Vygotsky‟s (1978) theory both emphasize that social interaction with an MKO is critical for cognitive development in children. While thinking may develop in adults, most research presupposed that critical thinking does not develop in children (Chikiwa & Schäfer, 2018). However, they also pointed out that research supports those aspects of critical thinking. It appears that critical thinking, which is more complex, needs to be simulated. This is enabled by a teacher or an MKO aided by the social environment within which learning is facilitated.

Like (Dewey, 1916) theory, the natural environment in Rogoff et al.‟s (2003) theory is an important part of how learning takes place. The environment in *intent participation* facilitates a communal inclusive opportunity for the learner to participate. Rogoff et al. state that within the environment the leaner is on the outskirt keenly observing without initial participation and, although expected, is given the choice to contribute within a reasonable time frame. It is transmitted by cultural understanding. There is also a common understanding and involved in social implications that is not based on any specific criteria upon which the child initiates participation of common tasks.

All three theories posited by Rogoff et al. (2003), Dewey (1916), and Vygotsky (1978) are rooted in everyday life experiences in that the learner‟s experiences extend outside the perimeter of schools to the sociocultural environment; that is, such theories account for how a child is socialized by the various aspects of life such as school, home, culture, religion, and many other groups, which guide our beliefs, mores, and the way we perceive things (Sadovnik, Cookson, & Semel, 2004).

Fletcher (2017) argued that though mathematics educators in Ghana wished to follow a constructivist approach in the teaching and learning of mathematics, teachers at the basic and senior secondary schools continued to give too much prominence to memorization and 'imitation' instead of helping students to understand and explain Classical philosophies (realism, logicism, formalism, neo-realism, intuitionism naturalism) in relations to theories of learning mathematics. Whether the approach of Ghanaian mathematics educators in teaching, the fundamental cultural indicators must be envisaged. There must be a closed gap between mathematics been formal and informal.

According to (Putra, 2018), Ethnomathematics can bridge the gap between Informal and Formal Mathematics in Mathematics Learning Process at School. He developed a framework to that effect. An important issue in mathematics education in many countries has long been how to make use of students' daily life mathematics (informal mathematics) in teaching mathematics at school (formal mathematics). This idea help to propose an alternative framework of mathematics education that bridges informal and formal mathematics using ethnomathematics (Putra, 2018). Ethnomathematics can be defined as mathematical techniques or styles in explaining, learning, knowing and coping with natural, social, cultural and even imaginary environments (D'Ambrosio, 2006). Putra (2018), shows how ethnomathematics can act as a bridge between formal and informal mathematics in an Indonesian context, using a dialogue between three personifications of ethnomathematics. These are formal mathematics and informal mathematics: (1) Ethios (a personification of Ethnomathematics); (2) Meukhop (a personification of Informal Mathematics); and (3) Geom (a personification of Formal Mathematics).

2.2. 4 Mathematization process

A multiplicity of definitions of mathematization emerges from the diverse fields of mathematics and sociocultural contexts. These differences in definitions, which can be attributed to the distinct environments in which they are developed, contribute to the evolution of the diverse features of mathematical ideas, procedures, and practices. Mathematization is one of the major mathematical processes that can help best transcribe and translate more Akan indigenous ethnomathematics from informal mathematics to the formal one, by bridging the gap as (Putra, 2018) did.

These facets of mathematical knowledge suggest the development of different and often unique forms of mathematization so that members of distinct cultural groups are able to understand and comprehend their own cultural, social, political, economic, and natural environments. This means that these members develop unique ways to mathematize their own realities (D"Ambrosio, 2001).

From an ethnomathematical perspective, mathematization is the process by which members from distinct cultural groups develop tools that allow them to organize, analyze, describe, comprehend, understand, solve, and translate mathematical ideas, procedures, and practices present in specific phenomena that occur in their own sociocultural environment so that others can understand their findings (Mariani & Hendikawati, 2017; Wardono & Hendikawati, 2017). This approach helps them to schematize, formulate, and visualize a given problem in different ways. It also facilitates the discovery of relations and regularities so they are able to translate these problems into academic mathematics (Rosa & Orey 2013a).

Mathematization is also a transformative process that translates real world phenomena into academic mathematics by developing and communicating the notations, representations, vocabularies, and algorithms in order to enable students to generalize and make conjectures (Hidayat, Wardono, & Hendikawat, 2019).

In this regard, the ability to mathematize is essential to the development of numeracy skills since it helps students to elaborate appropriate responses to a wide range of personal, institutional, and societal needs (Eglash, Bennett, Drazan, & Lachney, 2017). Numeracy abilities such as analysis, interpretation, and the use of mathematical information allow students to make decisions and judgments and to support or challenge arguments that enable

2.2.5 Epistemological review on ethnomathematics education

A multicultural class is fertile platform for the growth and extension of mathematics. So, different Ethnomathematics are arisen from practice of multicultural on a mathematics class. Ethnomathematics relates cultural anthropology, institutional mathematics and utilizes mathematics model to solve real-world problem (Orey & Rosa, 2004). In Venn diagram it can be represented as:

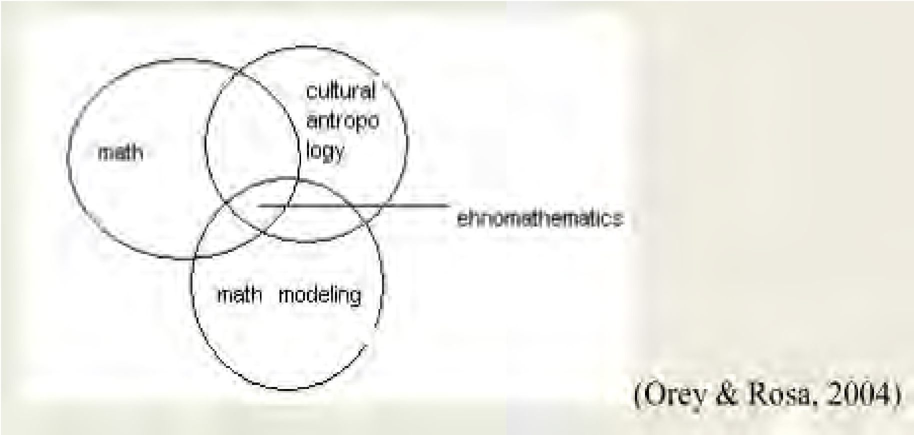


Fig 2.2: Venn diagram showing relationship between ethnomathematics and other epistemologies. Source: (Orey & Rosa, 2004)

Thus, the main purpose of Ethnomathematics program is to relate between pure mathematics, cultural anthropology and mathematics modeling. Accepting and rejecting Ethnomathematics as constructive factor of future mathematics (Izmirli, 2011). Ethnomathematics is the central point of mathematics, modelling and cultural anthropology (Orey & Rosa, 2004).

Epistemological, related with the way ethnomathematics positions itself in terms of mathematical knowledge; and pedagogical, related to the way ethnomathematical ideas are implicated in formal education. After a description of both of these categories, the pedagogical implications of ethnomathematics are considered by means of confronting the criticisms of recent research in the field (Rosa & Orey, 2015). Ethnomathematics research conceives its pedagogical implications in different ways, some of them contradictory. Such contradictions are related with the societal role of school, with the idea that we can "transfer" knowledge from one setting to another and the tendency to reduce ethnomathematics to a ready-to-apply "tool" for the school-learning of mathematics. The author discusses the first two criticisms in the light of recent research concerned with the social and political dimensions of mathematics education.

2.3 Empirical Review

This section of the chapter review literature on empirical evidence on works carried on ethnomathematics, mathematical constructs and curriculum from informal to formal conceptualization of mathematics teaching and pedagogical developments. Evidences supporting cultural implication to mathematics pedagogical teaching strategies are looked at.

2.3.1 Mathematical Constructs and Their Applications in Mathematics Education

The mathematical construct is looked upon by many mathematics educators with a different eye. Some consider it to connote the content discussion on mathematical construction as a topic relating to Euclidean geometry. To some, a mathematical construct is seen to be the concept frame that serves the bases of the topic taught. We discuss this section of the review to the later part of these school of thoughts. That mathematical construct is viewed to be the topical concepts that governs the understanding of the mathematical topic the teacher facilitates and introduce to students.

Issues relating to mathematical construct have been viewed by severally as the topic “construction”, which conform to Euclidean geometry. Quite contrarily to this is to look at mathematical construct as the conceptual frame surrounding topics taught under the mathematics curriculum. It is the bases by which mathematical contents are developed to form a mathematical topic by which the mathematics curriculum specifies for teachers to teach (Clementi, 2018). Perception and attitudes attached to mathematics content has been concluded by researchers as negative, perhaps, because of the nature of the content. This has thrown a challenge to mathematics educators to find various ways of controlling and attracting people to love studying mathematics. Students who are believed to possess positive attitudes towards learning mathematics can understand mathematical content better than with negative attitudes (Mokgwathi et al., 2019).

Mathematical construct plays several roles in learning situations as evident in (Massarwe et al., 2010) research. They see mathematical constructs as instruments used to model real-world situations and events, or as an object of reasoning. Mathematics is a particularly abstract domain because the affordances and constraints underlying the use of mathematical constructs may be the difference between the affordances and constraints in real-world situations. The content-based of mathematics is seen by many as the topical issues by which the curriculum dictates to instructors.

Zhang, Sun, Han and Sun (2018) sees mathematical constructs as something connected to "*Automatic Generation of Combinatorial Test Data*". They present some typical mathematical methods that are commonly used in the construction of orthogonal arrays and covering arrays, as well as some bounds on the size of such arrays in various mathematical constructs. Zang et al. (2018) discuss various mathematical constructions beyond Euclidean geometry but a discrete form of mathematics such as juxtaposition, Hadamard construction, zero-sum construction, simple constructions, and recursive constructions. Hence mathematical constructs go beyond geometry. It takes various forms best known to the mathematics educator.

The concepts of mathematics taught however should be linked to the level in which the curriculum prescribes for. The basis of the constructs defined on mathematics could be linked to theories, algorithms, lemmas, prepositions, postulates and among another computational form of the content based on the subject under discussion. In Ghanaian secondary schools, the content is specified by what Ghana Education Service (GES) under the Ministry of Education (MOE) outlines as mathematics curriculum for the various class teachers (MOE, 2012). The content scope of the mathematics syllabus is geared towards seven broad areas: Numbers and Numeration. Plane Geometry, Mensuration, Algebra, Statistics and Probability, Trigonometry, Vectors and Transformation in a Plane, Problem solving and application (mathematical processes). Cultural diversities and ethnomath support all these mathematical topics. Among all these, most prominent topics which are supported by ethnomathematics may include mensuration, trigonometry, statistics, and number and numeration concepts.

The nature of mathematics concepts cannot be separated from science. Students view of mathematical concepts makes them appreciate the beauty of mathematics or otherwise, make them hate the subject causing abysmal performance. Successful academic achievement of students in mathematics depends upon the kind of attitude they deployed towards mathematical content (Shaheed, 1994; Farooq et al, 2018), affirms that students who even fear the subject mathematics even extend some level of hatred for the teacher who teaches it. To Russo and Hopkins (2018), students having a positive reaction towards the mathematics teachers depends on classroom culture that embraces the struggle of understanding the mathematical concepts, high teacher expectations as well as consistent classroom routine processes (Sunzuma & Maharaj, 2019; Mahpudin & Sunanto, 2019).

Conventional mathematics education leads to a fabricated view of students who think that mathematics is an isolated field of science from their daily lives this is because they hardly find any relevance of what they learn to their day by day life situations. Learning mathematics through the precepts of ethnomathematics can bring mathematical ideas closer to students' daily lives so that students can better understand and interpret the learning outcomes they get from the mathematics educator. In addition to this, Mahpudin (2018) agrees with Oray et al., (2016) that ethnomathematics can promote and develop multicultural competencies in students. Students can better know and appreciate cultural diversity and its interplay informal education systems.

Teachers‟ choice of topic to teach is based on what he already knows from his hay days in the previous school. Curriculum developers think to mathematical structure content from a hierarchy of mathematical content learning task. For example, Ghana Education Service CDDR tries to structure mathematics content from pre-school number system, to primary school, JSS and move higher into the Senior secondary school level. The concept of the topic *set* from primary class one is different from that of JHS and slightly different from that of SHS. It is generally acknowledging that mathematical constructs are related to what content or task is specified and what mathematical concepts guide its understanding. Hence epistemological believers put it as "part of teachers‟ professional competence" and this impact their selection of learning tasks as well as their instructional activities in the classroom (Rusmining, 2017; Depaepe, De Corte & Verschaffel, 2016). Many researchers have the conviction that, mathematical concepts and constructions dictating teachers‟ lessons is based on epistemology which is not indifferent from every teacher‟s move towards what is to be taught to class (Frankenstein & Powell, 2002, 2009; Izmirli, 2011; Rosa & Orey, 2015; Blomeke, Feucht & Bendixen, 2010; Kunter et al., 2013; Feucht & Bendixen, 2010; Depaepe, et. al. 2016).

The content of mathematics in the formal setting is deemed difficult as perceived by some areas in mathematics. For instance, the concepts of measurement and fractions have been cited as being difficult for Ghanaian pupils (Khan et al., 2015; Davis & Hisashi, 2007; Davis, 2004; Davis & Ampiah, 2009), are all deeply rooted in the Ghanaian culture. Mathematical construction is topically focused, and it behoves on mathematics educators to help learners crack the shell well in which level of education the curriculum suggests to be taught.

Suyitno, Florentinus, and Zakaria (2018) see mathematical constructs as something connected to generic skills that serve the bases of learners understanding of the mathematical concept taught. One of the skills that must be relatively hard by the learner after learning mathematics is the skill to think critically about what is taught in class. Critical thinking and computational skill, according to Suyitno et al., (2018), is necessary to solve a mathematical problem that is confronted in daily life as supported by (Gxekwa & Satyo, 2017; Uswatun, 2018; Isjoni, 2010). Hence, Critical thinking skill principally is needed in solving mathematical problems. It is the key attention in the learning process of any mathematical concept.

In teaching mathematical concepts herein defined to conform to mathematical construct at class, the teacher has to instil problem solving skill. There is the need for student to think critically in mathematics by linking mathematics problem with daily life and culture tenets of the people in the society (Alangui, 2017; Stathopoulou, 2017; Alangui, 2017; Cimen, 2014; Eyal, 2018). The learner is not only to get knowledge about mathematics but to know cultural values in society as well. This connection will undoubtedly foster students‟ cognition in mathematics lessons.

2.3.2 Mathematical Constructs and Concepts in the Context of Ethnomathematics

Mathematical constructs could be viewed in some informal settings where cultural diversities seem to support or throw evidence on some components of mathematical concepts that are supported by traditions and culture. Mensuration and trigonometry as topics are seen to be associated with students‟ prior understanding of similar concept informed from cultural artefacts. In (Karki, 2017) thesis report, basic mathematical concepts practised by Danuwar community in Africa is quite similar to most of the Ghanaian tribal communities. The counting system, measurement procedures mensuration concepts like volumes, areas, length and distance estimations as well as domestics‟ concepts of geometry was surveyed among the Danuwar community. Karki (2017) study is carried on cultural, historical, pedagogical and mathematics methodological perspective by making intimate ethnomathematics connection to the formal one binding Danuwar community. Most African tribal communities have similar informal educational patterns which inform naturalistic philosophy of mathematics. To some extent, ethnomathematics from cultural diversity explain the essence of the new field and new era in the history of mathematics education where the relevance of culture of the people to the formal education system is seen (Orey et al., 2016).

Imswatama et al., (2018) see mathematics and science as having a similar but unique characteristic. To them, mathematics and science are embedded with abstract object, the pattern on axiomatic and deductive thinking based on truth. This is further surveyed by Afandi (2018), Mursalin et al. (2018), Fazio, Bailey, Thompson., & Siegler, (2018) and Amalia et al. (2018). With such unique characteristic, mathematical content is covered with abstract constructs upon which content is developed. This arbitral constructs inherent within mathematics curriculum is useful in developing skill and creating not only the learner personality but also understanding the beautiful linkage to cultural diversity (Mawaddah, 2015; Flora, 2017; Setiawan, 2006; Trisnawati, 2018).

Sutisna, Budi & Noornia, (2019), refer to the extent to which developmental, educational, and experimental studies supports the view that a new understanding of mathematical concepts has cultural backings. Mathematical constructs serve as a powerful way of reasoning. This becomes conceivable from culturally arbitrated mathematical constructs. The belief of (Staut & Stern, 1997) links the notion that, to every level of the learners" education of mathematical concepts, let the awareness of what is found locally, on the basis of culture, direct our effort to structure the curriculum.

Davis (2016), investigated the impact of Ghanaian cultural way of measuring things, that is, ethnomathematics on pupils understanding of mathematical concepts of measurement. Among the Ghanaian people surveyed through market and pupils" pre-informed notions of measuring and sharing in an out-of-school situation, a connection was established to have influenced students understanding of mathematical concepts of measurement taught. Ethnomathematical constructs could be seen reflecting learners" conceptions and practices in school and hence help them understand mathematical concepts taught. Davis" findings from the study seem to endorse the local aspect of mathematical knowledge influencing the way pupils understand mathematical concepts on measurement. Davis (2016) however recommend the need for mathematics teachers to consider the implication of ethnomathematical study into the conventional means in which we deliver teaching. Integrating everyday life situations into school mathematical knowledge in the teaching and learning situation would enhance the understanding of mathematical concepts and construct within the curriculum.

Researches have wondered about how richer mathematics education would become if all and sundry educators should include integrating social principle in learners" education. Powell (1997) as cited in (Devkota, 2015)for instance, states that "the inclusion of mathematical ideas from diverse cultures can make the mathematics very understandable and recognises different practices of a mathematical nature in varied cultural, procedural contexts". If students" experience from their cultures can be linked to academic work in mathematics class, it will help bring meaningful learning to the students. The results of this would help them adjust to the related mathematics curriculum from all educational hierarchy ahead. To (Abdullah, 2017)

To Banks (2002), culture is to apply to all features of life development, the entirety of implications, philosophies, and views shared by individuals within a group of people. If learners do not get meaningful understanding from mathematical concepts taught in school and reconcile its relevance to their immediate environment, society, tradition, culture or perhaps technology, they will grow and hoot at mathematics as irrelevant and perhaps mock the mathematics teachers who taught them.

The relevance of mathematics has been the concern of humanity. The essence of new mathematical ideas initiated by scholars is based on a struggle to solve societal problems. Hence mathematics plays a significant role in the learners" interest in meeting society"s *survival of the fittest* in this direction. According to (Celik, Bindak, & Ozdemir, 2018; Hayden, 2010), One of the numerous roles of mathematics is to prepare learner in order to be able to face the changing condition or challenge in life, for which, notwithstanding academic focus, develops towards societal interest, (Tessa, 2001; Haydon, 2010; Woods, 2010). The curriculum structure of the people usually specifies the general goal of teaching mathematics. The learner is expected to be able to apply mathematics and thinks mathematical in daily life, (Ruz, Ruiz-Reyes, Molina-Portillo, & Díaz-Levicoy, 2018; Yusrina, 2017; Artut, 2009). In mathematics class, the learner is not only to understand the mathematical concept or construct, content, topic and theory in solving problems but also to use it to solve societal problems. (Brosh, Root, Saunders, & Spooner, 2018; Mawadah, 2015), see students" ability to solving a mathematical problem as having connections from knowledge and experience gained as they interact with mathematical concepts. For students to understand mathematical construction of contextual ideas that govern problem-solving, experience from what they know should be established. It is an indisputable fact that students experience is also connected to the culture of the people,

2.3.3 Mathematical Construct and Reasoning.

Different perception, interpretation and concern is given to the nature of mathematical reasoning as a result of the constructs imprinted in the content and concept description enshrined in the curriculum. Mathematical reasoning is perceived by (Karataşa & Akyüzb, 2018; Karataşa & Akyüzb, 2018) as a high-level cognitive process which involves interrogating a problem or phenomenon to arrive at a reasonable result. The focus of 21-century learning is to consider students as constructors of knowledge; rather than merely consumers of information (Mesquita, 2017; Bada & Olusegun, 2015). This shift from the traditional teacher-centered approach to learning has redefined the meaning of mathematical proficiency; thus, affecting pedagogical practices within mathematics classrooms. Therefore, educators and researchers alike are pressed to develop teaching approaches that facilitate skill that will fulfill the mandate of new mathematics curriculums.

One important skill that seems as indispensable to doing mathematics is mathematical reasoning (Gürbüz, Erdem, & Gülburnu, 2018). Mathematical reasoning is seen as a high-level cognitive process, which involves interrogating a problem or phenomenon to arrive at a reasonable result (Karataşa & Akyüzb, 2018). Mathematical reasoning can be developed using carefully designed tasks (Mueller, Yankelewitz & Maher, 2015). Therefore, Stacey (2012) recommends that age-appropriate reasoning tasks, which are progressively sophisticated should be methodically included throughout a student"s mathematics experience. However, (Orey, 2017; Cheeseman, Clarke, Roche &Walker, 2016) points out that teachers often find it challenging to present these tasks to students in a way that is not daunting, but instead sustain engagement and exploration while maintaining an appropriate level of challenge.

Forbe (2018), drew mathematics educators attention to her ethnomathematics handbook as "A plausible way to attract students to mathematical reasoning activities is to give them the avenue to incorporate their cultural experiences, p. 67". In that way, tasks will be open, having low floor and high ceiling, as Boaler (2016) required for learning tasks that are accessible to all students. Low floor in that all students will have an access point and high ceiling in that the tasks will provide opportunities for challenge. The access point of the task would be culturally relevant problems that are initiated by students with guidance from teachers, and then develop through mathematizing and mathematical reasoning skills. Mathematical reasoning skills involve "generalizing/abstraction/modeling, ratiocination, development and creative thinking skills and the relationships among these skills" (Mumcu & Aktürk, 2017, p. 225).

Boaler (2016) point out that mathematical mindset is not only important for students in learning mathematical concepts but is also important for teachers, to inspire all students to learn and develop confidence in the subject. Boaler (2016) further asserts that students often develop trauma during the experience of learning mathematics, which prevents them from wanting further interaction with the subject. However, teachers can employ strategies to change students‟ mindset and boost their performance (Dweck, 2015). Dweck (2015) states:

> ...students who believed their intelligence could be developed (a growth mindset) outperformed those who believed their intelligence was fixed (a fixed mindset). And when students learned through a structured program that they could "grow their brains" and increase their intellectual abilities, they did better… having children focus on the process that leads to learning (like hard work or trying new strategies) could foster a growth mindset and its benefits. (p. 20)

Consequently, teachers aim at all times is to promote a growth mindset in students, whether in designing major task or merely giving instructions. Moreover, Dweck (2010) asserts that teacher should aim to create a culture of a growth mindset in the classroom. An ethnomathematics approach to mathematics teaching and learning inherently promotes a growth mindset. One of the key objectives of ethnomathematics is to dispel the hegemonic Eurocentric view that confined mathematics to a Western culture (Brandt & Chernoff, 2014; Brandt & Chernoff, 2015; Powell & Frankenstein, 1997; Bishop, 1990). It is concluded here that "Mathematics was created by people who needed to solve problems; it was not ordained from on high", (Katz, 1994, p.26).

2.3.4 The implication of mathematical construct to mathematics educators

Students understanding of the content based of mathematics have been the concern of most mathematics educators. Mathematics educators seek to find diverse ways of improving methodology in helping learners adjust to its understanding. Pedagogical development of the teacher is developed under the dictates of what content is needed to transmit to the learner. Teachers‟ choice of appropriate pedagogy in teaching mathematics and science is influenced by the level of content or concepts defined by the curriculum (Nabie, Akayuure, Ibrahim-Bariham, & Sofo, 2018; Mereku, Nabie, Awanta, and Appiah, 2011; Okpoti, 2001).

Preparation of teaching and learning materials to help the teacher teaches well is directed by what manner of content worth it. Investigation made by (Abadi et al., 2018), into "*The Development of Interactive Mathematics Learning Material Based on Local Wisdom, p.33*" Learning materials used by students and schools in Serang district are lacking because they do not contain local wisdom content. To (Abadi et al., 2018), the aim was to improve the deficits in teaching and learning aids used by students by making interactive teaching aids based on indigenous knowledge of the local people. The results were proving to contribute positively towards the teaching and learning of the concept initiated in making these interactive learning materials by the stages of the ADDIE study. The results of their study included interactive learning materials based on local wisdom prove to help students understand the content. In investigating the cultural wisdom in mathematics (Mariana, Anggraini, & Kusniarti, 2018) recommend that the learning materials that the mathematics educator should make should have local wisdom additional interactive content. Recent technology in education has offerred educators a variation of new tools used in the classroom to facilitate learning, (Akbar, Firman, & Rusyati, 2017). Interactive learning materials should be used on smart android phones and computers.

Mathematics teaching material based on ethnomathematics proves useful toward solving problem skill and student mathematical critical thinking. Besides, by applying mathematics teaching material that is improvised from cultural environment, that is from ethnomathematics can raise student involvement in class activities during mathematics lesson, Imswatama (2018). Others are of the view that, modern form of teaching should go beyond improvisation, but rather employ the current form of technology in the teaching of science related subject (Ormanci & Cepni, 2019). Mathematics teaching is not quite different from science. Sometimes, mathematics teaching and learning goes beyond the use of modern technology. Its seeks to employ basic primary tools and materials. Artifacts and among others that have connections to culture of the learners (Oray, 2016).

The essence of ethnomathematical studies that guide mathematics educators for streamline teaching of mathematical constructs and concepts is to fulfill curriculum implementation. Hence, mathematical constructs help teachers to adapt and implement the curriculum that suggest specific content discussion to specific class, level or grade. Ní Ríordáin, Paolucci and Lyons, (2019) assert that so far as teachers remain the forefront practitioners of education, it is important to maintain a focus on the development of not only specialized content knowledge but also the essential skills and practices necessary to enrich our competent teaching to fulfil the aim of curriculum.

Mathematical construct, as a conceptual framework surrounding the teaching of mathematical contents has the Role of ethnomathematics in support of content teaching. It is in the light of this that Mawadah, (2015) recognizes the core mandate of the mathematics teacher to be able to assist the learner and give meaning to mathematics concepts learnt. This would help build the skill of student mathematical problem-solving skills to deepen student‟s understanding toward mathematical skills and concepts. Ríordáin et al., (2019) see the importance of teacher knowledge based in the mathematics itself before teaching it. Hence the development of teachers‟ core practice both in-field and out-of-field practices give the opportunities to incorporate appropriate pedagogical skills in the teaching of mathematical concepts. Many of "out-of-field" practices suggested by Ní Ríordáin et al., (2019) adopt an implicit approach to the role of cultural diversity in as much as teachers explore the environment to support in-field teaching of mathematical concepts.

Teachers‟ knowledge of mathematical concepts would help them adopt Meaningful teaching of mathematics content. For ex ample, (MacDonald, Lord & Miller, 2019) used a small set of both teachers and students discourse moves as meaningful teaching approach of mathematical concepts. To them an appropriate teaching methods centers on English Language Learners where discourse analyses would help deepens students‟ mathematical reasoning. Thus, one advantage of mathematical concepts is for teachers to adapt meaningful learning strategies in ensuring students understanding of mathematical concepts and problem solving skills, (Macdonald et al, 2019).

2.3.5 Ethnographical View on Numeration and Number Concepts

An investigation by Supiyati, Hanum & Jailani, (2019)) drew on results from psychology and from cultural and linguistic studies, and argue for an increased focus on developing quantity sense in school mathematics. They explored the notion of "feeling number", a phrase that we offer in a twofold sense; resisting tendencies to feel number (more-numb) by developing a feeling for numbers and the quantities they represent. First, they distinguish between quantity sense and the relatively vague notion of number sense. Secondly, they considered the human capacity for quantity sense and place that in the context of related cultural issues, including verbal and symbolic representations of number. Thirdly and more pragmatically, they offered teaching strategies that seem helpful in the development of quantity sense coupled with number sense. They finally, found out that there is a moral imperative to connect number sense with such a quantity sense that allows students to feel the weight of numbers. It is important that learners develop a feeling for number, which includes a sense of what numbers are and what they can do, (Hardegree, 2003).

2.3.6 Ethnomathematics Implications

The ethnomathematical study has been helpful in suggesting a more learner-friendly approach towards studying mathematics. Mathematical concepts under various generalisation and modelling approach in the formal systems makes it challenging to mix school mathematics and ethnomathematics (Rosa, 2000; Rosa & Orey, 2003). Learners" practice of academic mathematics herein referred to as formal mathematical education system learn to model situations which are generated from their socio-cultural perspective (D"Ambrosio, 1993). Students interaction with school mathematics prescribed by the curriculum that is implemented through the ethnomathematics principle makes it meaningful. The subject could be meaningful especially when they are encouraged to solve problems that are related to their communities. Mathematical modelling acts as a conduit linking ethnomathematics and Western-academic mathematics that are essential for the student"s academic achievement in today"s globalised technological society (Orey et al., 2016).

The informal educational systems among most African communities have some restricted cultural bounds. Abonyi (2016) sees ethnomathematics as the science of body of numbers and its influences that are entrenched in the people"s native culture. Imprints of mathematics manifest in peoples" cultural artifacts such as mats, clay pots, clay bed, houses (round and rectangular), decorations, baskets, local drums and fish traps (Abonyi, 2015). There is the need to merge ethnomathematics into culturally relevant pedagogy and some theoretical framework that should govern the formal curriculum structural system (Scott, 2018) investigated in his thesis, a multicultural educational approach which proposes a shift in mathematics education where culturally relevant approach needs to be adapted into the formal curriculum.

There should be an advocate on the emotional and love for teaching and learning mathematics. It is high time educators" canvas on how to assist students to develop a positive attitude towards the study of mathematics so as to perform well in the subject. In this directive, Bean, Folkes and Ellison, (2019) introduce the term "teaching in a culture of love" to debunk these models and instead seek to value diverse students and families" lives both within and outside school communities

2.3.7 Nature of Formal Mathematics Education System in Ghana

The current system of mathematics education evolves from different paradigms. The standard for mathematics curriculum from the formal perspectives and mathematics education, in general, have evolved in various ways. The structuring, sequencing and addition of new concepts keep on reminiscing (Presmeg, 2002). Curriculum changes are on rigorous transformation based on educational policies influenced by government systems, especially in Ghana. Oray and Rosa, (2006) put it that, it has been challenging to mix the general goals and the naturalistic philosophy of ethnomathematics, academic standards, principles, and goals related to the passing of standardised exams that conforms to traditional school mathematics systems (Rosa, 2000). Stakeholders including teachers, management and educators sense that their students will not take mathematics contents learning seriously if they use an ethnomathematical approach in school curricula. There is the belief that mathematics idealization makes students and teachers accountability in standardized examinations. This has created an extreme problem of considering ethnomathematics as a waste of students and teachers time in meeting probably WASCE requirement (Clark & Napp, 2013).

Quite occasionally, West African Examination Council (WASSCE) tries to assess students" application of mathematical content by merging application to ethnomathematics (see fig 4.8, SSSCE 2009 past question).

2.3.8 Formal Mathematics Curriculum Structure: The School Curriculum

The curriculum is all the experiences a learner acquires from the school system or any organisation. However, the school curriculum is structured to conform to some formal and standardised Eurocentric convictions (Obodo, 2004; Eshewari, 2009; & Fasheh, 2002). Any curriculum should have an aim, objectives, content, method of teaching the content and an assessment procedure. The third objective of the SHS core mathematics syllabus is for students to "Use mathematics in daily life by recognising and applying appropriate mathematical problem-solving strategies" (CRRD, 2010, p. 2). The issue of "daily life" is connected to the students" interaction to his adaptive cultural environment to which ethnomathematics should address.

Different meaning of the conceptual definitions of the curriculum has been considered over some time with authorities not drawing conclusively as to what the term means (Fouze & Amit, 2018). While some curriculum consultants have limited this to the realm of academic pursuit only, there are others who have argued with the non-academic meaning to the term curriculum. Can we consider our informal traditional type of education as having some curriculum based? Maybe the traditional informal curriculum is seen as unwritten and subjected to have an oral transmission. Booker (2009) put the curriculum into three perspectives as the „intended", the „implemented" and the „attained". The predetermined phase of the curriculum is what an institution like the Ghana Education Service (GES) outlines in their various syllabuses to be used by schools under her jurisdiction. The implement aspect is the one few teachers use in classes. The attained part of the syllabus according to Traverse et al., is part of that part of the syllabus the learner can retain out of the implemented part of the curriculum. Whichever form the curriculum takes, its implementation is paramount to the interest of all stakeholders and the nation at large. There is the need to for mathematics educators to play their part well by considering its implementation along ethnomathematics pedagogies.

Ghanaian official school mathematics curriculum according to (Mereku, 2013) comprises textbooks, teachers‟ handbooks, and syllabus. This listed component of the curriculum has a widespread impact on classroom practice in Ghana, to him, even few teachers have access to them. An investigation done along finding out "the congruence between the teaching methods presented in the official curriculum materials and teachers‟ classroom practice" revealed that, both the official curriculum and the teachers, who implement it, consider the use of "expository teaching methods" (Mereku, 2016). If this method so interests this Ghanaian curriculum implementers, it can be linked to ethnomathematics approach to induce learners understanding. Perhaps this could help realise the third general objectives the curriculum specified.

Curriculum adaptation at the classroom level may be evidenced by differences between formal curriculum requirements, in terms of content and pedagogy, and the amount of curriculum actually covered during classroom teaching (Smylie, 1994) as cited in (Mills & Mereku, 2016)

2.3.9 Suggestive Way of Merging Ethnomathematics to School Formal Systems

The ethnomathematical study from informal perspective needs to be reconciled with the conventional Eurocentric formal education systems. The curriculum structure and mathematics educators" effort in implementing it needs to adhere to *mathematization* of culture. Orey and Rosa, (2006) define Mathematization as the development of a given problem, that is, the transformation of the problem into mathematical language. To them this can be realised by the formulation of the hypotheses surrounding the ideal concept we need to mathematicise. We can also classify social data and traditional mathematics systems to conform to the bases of pure mathematics systems from Western mathematics idealisation. Some of the information from socio-cultural perceptive can be important and non-important to the hypotheses binding the merge of the curriculum. Selection of essential variables, symbols, materials and artefacts adapted from a cultural description of those relationships in mathematical terms can be linked to serve exampling base for topical issues in the formal mathematical concepts thought (Orey et al., 2006).

Ozofor and Onos (2018), experimented the use of the ethnomathematics methodology on teaching some selected topics including probability in some senior grade level. The ethnomathematics approach used affected students" academic achievement more positively than the conventional technique used in teaching another controlled group in selected topics in senior grade level. It enhanced and facilitated higher and better performance in mathematics. We are of the view that, when we embed similar approach in teaching suggested scope of topics specified by the school syllabus, students would appreciate better. Ozofor et al. (2018) experimental study on the use of ethnomathematics to teach control and experimental groups also revealed that gender did not affect ethnomathematics method so far as teaching and learning is concerned. Students‟ performance achievement is not biased towards the use of ethnomathematics approach. Again the findings revealed that the ethnomathematics approach was more operative in nurturing and motivating learners‟ interest in the lesson more than the conventional Eurocentric teaching method

There is this attitude of African mathematics educators whose methods of teaching mathematics is dictated by foreign practices by neglecting the cultural bearing of content taught (Obodo, 2004). Such method used is rooted in the British culture, and this allows students to learn by rote memorisation. The conflict between culturally known problems (ethnomathematics) and unknown problems of the learners (Eurocentric approach) throws confusion in the mind of the learner as they struggle to comprehend mathematical concepts. This gives little or no room for the practical aspects of students‟ life as the curriculum is aimed at achieving. The method of teaching and learning of mathematics in Africa context is echoed by several mathematics educators who have the ethnomathematics naturalistic ideology (Eshewari, 2009; Fasheh, 2002; Obodo, 2008; Fouze & Amit, 2017).).

In order to put an end to the poor performance and students interest in mathematics, Chief examiner report of West African Examination Council (WAEC, 2007) have recommended that mathematics teaching method should be practical, applicable and project-oriented (Obodo, 2008). Even though, ethnomathematics approach is silent in the suggestion, the essence of making mathematics lesson practical still boils down to the fact that, we should let the learners explore their environment. The discovery approach to the teaching of mathematics as against teachers‟ dominant choice of Expository method as investigated by (Mereku, 2016) can adapt the ethnomathematical approach to guide teachers‟ choice of their methodologies. Recent research studies have employed a variety of methods of teaching mathematics. Such methods include discovery, expository, laboratory, inquiry (Kurumeh, 2004), target-task, delayed formalisation, computer-aided instruction and problem-solving method (Harbor-Peter, 2000). We propose a connection between these methods to ethnomathematics to develop learners" interest and understanding of the mathematics we teach.

2.3.10 A Multilingual Effect on Mathematics Education

Parra et al (2016) examined "challenges and possibilities for the development of Indigenous mathematics education in multilingual contexts", based on existing research carried out in Brazil, Peru, and Colombia. The relationship between language policy and educational policy, as well as bilingualism and its implementation in relation to Indigenous education has been explored. Para et al repot on discussion of the development of mathematical registers and language revitalization as central issues within the mathematics education of Indigenous people, (Para et al, 2016). In Ghanaian educational system, GES has stipulated a unilingual language policy in the teaching of mathematics in the educational system where L1 (local first language of the child ethnographic disposition) is used to teach early childhood education up to class/grade 3 and L2 (English official second Language) used to teach upper elementary school up to the tertiary levels (Baffoe & Amoah 2015)

Bender and Beller (2018), looked at numerical cognition is a textbook example of how tightly cognition is intertwined with language and culture, as the ability to accurately assess, remember, and reconstruct numbers beyond the subitizing range (i.e., 1–3 objects) requires a cultural tool in the form of counting sequences. These sequences may be realized in different modalities (material, body-based, verbal, or notational), and they constitute numeration systems with distinct structural properties, the cross-cultural variability of which has implications for number representation and processing. Adopting a *distributed cognition* approach to cognitive tools, we describe four commonly used numeration systems with respect to their properties and cognitive implications, analyze inconsistencies between these systems, and identify some challenges and opportunities for learners arising from their coexistence. In so doing, we also draw more general conclusions on the relevance of culture and language for both the evolution and development of numerical cognition. Baffoe and Amoah (n.d), looked at the right type of language to use as a medium of instruction in schools has been a thorny issue to contend with for some time now.

Ghana, like many African countries, has not been spared of this challenge of choice. In fact, it has become a major matter of concern to many of us. Findings say children who are taught in their mother tongues tend to grasp educational concepts and principles faster and easier than they do when taught in other languages. It has also been established that the use of mother tongue as a medium of instruction in early grades of education sets the tone for effective acquisition of any other language. Language policy on education in Ghana, by way of history, has undergone several metamorphoses. A cursory look at things has shown that our nation did pursue a Dual Language Policy before 1925. The Wesleyan Missionaries, who settled along the western coast of then Gold Coast, used English Language as a medium of instruction in schools while Ga, Ewe and Twi were used along the eastern coast and inland parts of the country by the Bremen and Basel Missionaries. These local languages were developed and effectively used by the missionaries. Ofosu-Appiah (1976) identifies that, "as far back as 1872 Arithmetic was taught wholly in Twi and Ewe and the Twi and Ewe Grammars and Dictionaries were among the best in the world of scholarship,

p. 34" The use of mother tongue as a medium of instruction was strengthened by the passage of the 1925 Education Ordinance, which made Ghanaian languages a medium of instruction compulsory from primary one to three and as a subject of study at primary four while English Language was used from primary four onwards. This arrangement existed until our political independence when English Language became the medium of instruction even from primary one. The Local Language Policy was revisited, switched off again and back. Pupils from kindergarten one to primary three now are instructed in local languages. It is interesting to note that out of over sixty identifiable Ghanaian languages, fifteen have been developed and eleven out of the fifteen are studied at the various levels of our educational system, including universities.

At the non-formal level, all the fifteen languages are being studied. The Dzobo Committee Report (1974) on "The New Structure and Content of Education in Ghana" suggested the use of Ghanaian languages as a medium of instruction in the first three years of child education. The Report prescribed that, "The child should learn his own language in the primary school and in addition one other Ghanaian language. English should gradually become a medium of instruction as from primary class four". It moved on to make compulsory the study of a Ghanaian language in addition to other subjects in secondary schools. Teacher training colleges made their students to learn their native languages and one other Ghanaian language. Interestingly enough, this policy, which lasted since 1988, still exists though there have been a series of reforms. As we speak, the Ghana Education Service (GES) implements a policy which gives prominence to the study and use of Ghanaian languages in all our basic schools. It is a bilingual approach to the study and use of Ghanaian language and English at the kindergarten to primary three levels. It is helping to improve the ability of pupils to start reading and writing in their local languages.

The focus of the NALAP concept is to imbibe in the child the love for his or her local language and the ability to communicate in it effectively as a step towards the acquisition of a second language (in our case the English Language). The study and use of Ghanaian language does not terminate at the early grades of primary school. It continues with English Language as a subject till the end of basic education and beyond where it is run as an elective course of study at the secondary and tertiary institutions. Several factors contribute to low achievement of pupils. Scientific evidence suggests that there is some correlation between the ability of the child to use the native language and his or her command in the use of any other language. GES, in its Complementary Basic Education (CBE) programme, also believes that the use of local language in preparing instructional materials makes teaching and learning effective and stimulating

2.4 Conceptual Review

In this section, a conceptual framework surrounding this research is given. We discuss the nature of formal and informal mathematical construct, what constitute a mathematical task, Realistic Mathematics Education (RME) and its implication to pedagogical development of mathematics education. It is of prime motive that the study operationalizes ethnomathematics which is not so common in current literature where more light is thrown on theoretical frame work on ethnomathematics (Peni, 2019). There is a discussion on brain-based learning model implications which is perceived to support the pedagogical development of ethnomathematical lessons (Forbes, 2018). The researcher reviews the research conceptual framework to be used to carry out his investigations in connection to supporting evidences on the ethnomathematics pedagogical actions to operationalize ethnomathematical constructs among the Akan communities in Ghana.

2.4.1 Nature of Informal and Formal Mathematics Education (construct)

There are quite some informal educational systems within multicultural systems that can promote learners understanding of mathematics. Ethnomathematics, the pedagogical action of the ethnomathematical support system, can give a good understanding of the mathematical aspects of culture and having a clear drive to the educational activity such as curriculum structure. We do not, however, have a formal curriculum structure that fully supports the foundational ethnomathematics concepts. The consequence of these ideas is that ethnomathematical work in the schools is not a simple presentation of cultural examples or directly situating mathematics in cultural contexts by which the formal system can support. Instead it requires considerable background work, complete understanding, and pedagogical sophistication (Amit & Quoder, 2017; Irawan et al., 2019; Machaba, 2018; Orey, 2017).

An ethnomathematics approach encompasses all aspect of the curriculum (Aikpitanyi & Eraikhuemen, 2017) as cited by (Forbes, 2018). Orey and Rosa (2012), probe the question to researchers that, what practices do teachers engage to allow students socialise and to feel the essence of doing mathematics. The kind of perception teachers have towards students‟ mathematical identity is of paramount interest. Mathematics educators who appreciate the beauty of patriotism tries to make connection of Eurocentric nature of mathematics to the ethnomathematical concepts.

Orey and Rosa (2006), look at a way by which the traditional mathematical curriculum permits the application of ethnomathematical perspectives in understanding mathematical concepts conceived in the formal curriculum. To them, many challenges are there to constraint its application. This challenge hinge on how ethnomathematics characteristics are designated to conform to student experiences or from their environment and community. The informal educational paradigm is culturally rooted. There is no traditional *syllabus* or assessment standards and tools used to streamline it. People who cannot interpret culture are deemed traditionally ignorant and are reprimanded orally. Ethical respect is given to the one who admits a practical application of cultural precepts in traditional routine fashion.

Cultural values, traditions, and symbols are manifested in the life every society. Culture, therefore, occupies a very important place in human life and society, affecting economic, social, religious, and educational activities. Education in general and mathematical education in particular is also affected by cultural values. This essay discusses the importance of the development and implementation of math curricula that integrates cultural and folkloric elements and values from the daily life and society of the students, including folklore stories, games, and tools, and their contribution to increasing student motivation to study math, which in turn improves their academic achievements in this subject.

2.4.2 Realistic Mathematics Education (RME)

In Realistic Mathematics Education, mathematics educators provide the means by which mathematics abstractions is concretized to help students understand the concept better. Its implication revolves around realistic ethnomathematics which is very importance to the mathematics educator. The characteristic of Realistic Mathematics Education (RME) is that, realistic situations are given a prominent position in the learning process. The philosophy of RME approach itself is based on resourceful teaching (Sennen, 2018). It state that mathematics must be connected to reality and mathematics as a human activity. According to (Peni, 2019), students should not be treated as a passive recipient, but rather education should guide them towards using opportunities to discover and reinvent mathematics by themselves.

The integration of mathematical strands or units is essential as well in this approach. It is used to incorporate applications and implies that learning strands should not be dealt with as separate and distinct entities. In the Netherland, the implementation of RME and its impact increasing well. The implementation of RME was guided how best Mathematics educators can use ethnomathematics pedagogical actions to create linkage for teaching and learning of mathematical content (Sumirattana, Makanong, & Thipkong, 2017; Heuvel-Panhuizen, 1996). The secondary education as well got influenced by RME approach in their textbook. RME-based textbook series „Mathematics in Context" has a considerable market share in the USA. Not only that, RME-based or IRME (Indonesia Realistic Mathematics Education) also spread and smoothly develop at present. Even though silent on emphasis of RME model in teaching, a similar application is found in Ghanaian SHS core mathematics syllabus. Putting this action in place would help understand the impact of ethnomathematics in this context as (Peni, 2019; Sharples et al., 2019) suggested in their theory based on RME conceptual framework.

Three principles of RME like RME (Zulkardi, 2002) are:

1. Guided reinvention where student has a chance to reinvent by guidance of teacher.
2. Didactical phenomenology in order to find problem that can be generalize and can be use as vertical mathematization.
3. Self-developed models to bridge between informal and formal mathematics. The model and activity is made by the students in problem solving.

Some previous studies which focus on RME in Indonesia such as the one suggested by (Fiangga, 2013) using RME approach to help primary students understand the concept of area conservation in area measurement by using local instructional. In his study, he found out that *Tangram* as a real and precious media to learn shapes. Some researchers targeted the development of RME for the in-service and pre-service teacher. They try to do a project or develop such kind of training for them (Hardi, 2002). Based on those previous studies, the researcher only focuses on teacher or student only. Many activities for the students come from students' activity which is related to their environment from the game and daily activity which is part of the cultural activity as well. For example, playing, make a shape (design), etc, within students' game, we can find six universal activities by (Bishop, 1991).

Many of the Ghanaian traditional games are similar to Indonesia (Az-Zahroh, Thaariq & Surahman, 2019; Muhammad et al., 2019; Peni, 2019). For example, counting (jump rope), locating (hide and seek), measuring (marbles), designing (Tangram), playing, and explaining (more connected to communicating skill of the children). All those activities relate to mathematics activity for developing students' understanding of a certain mathematical concept. There is the need to find out how important cultural activity for the children especially in their development aged. Although this approach seems to be perfect pedagogical method in teaching, there are some problems that should get more attention: (1) in the situational level that used to be daily life context of the students, in the real implementation shown as application problem only not as a contextual problem, (2) separate the culture of the students during teaching using this approach may affect their thinking (Peni, 2019) and the last one (3) consider teaching resources different from the culture.

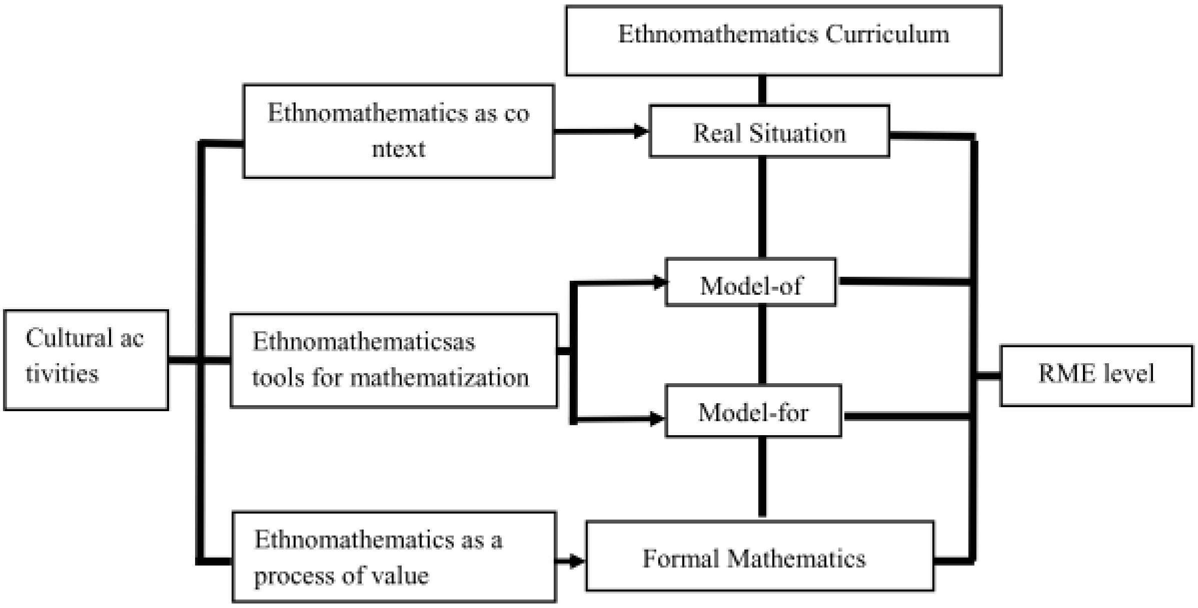


Fig 2.3: RME model for ethnomathematics (Peni, 2019)

Implications of RME to mathematics educators from figure 2.2 is clearly specified. Cultural activities bring out ethnomathematics concepts that has a clear connection to the formal teaching of mathematics such as geometry (Muhammad et al., 2019). Students and teachers alike needs to mathematicise the ethnomathematical constructs in order to create connection to the formal mathematical construct. Through this, the value of mathematics become paramount and students start to appreciate mathematics studies since the content is drawn to the doorsteps of the minds. From the framework model of (Peni, 2019), ethnomathematics curriculum from informal positions create Real life situation in mathematical studies that is made-of or made-for formal mathematics. To achieve this, RME level of cognition must be employed to bring about effective pedagogical action for teaching the required concepts.

RME provides a clear understanding to students about the relationship between mathematics and daily life as well as the usefulness of mathematics in general for humans. Mathematics is a field of study that can be constructed and developed by the students themselves and by others, not only by those who are called mathematicians. Again, it teaches students how to solve a problem. The process of learning mathematics

Figure 2.4: Mapping means that new knowledge is connected to previous knowledge and the new knowledge becomes a part of the current learning system. Keleş and Çepni (2006) as cited in (Gözüyeşil & Dikici, 2014). Brain-based learning is theoretically established on twelve principles of the brain. Educators who use ethnomathematics pedagogy may also use these principles by (Caine & Caine, 1990) as a frame of reference to guide their practice. The following table outline these twelve principles. There are three columns. The first two column summarizes Caine and Caine (1990) work on the twelve brain principles and their implication to education, respectively. The third column, cultural connection, explores how an ethnomathematics approach to teaching and learning measures up to brain-based learning.

Relaxed alertness:

Relaxed alertness means that teachers should aim for an environment that is of low threat and high challenge to accommodate teaching and learning. In other words, an environment that eliminates fear but also is highly challenging to sustain engagement and inspiration within learners. Many may reason that educators should aim to understand the background of students, but, how likely is this within a diverse classroom of the 21st century where diversity is ubiquitous and has ever-changing factors. Therefore, since it is not at all possible for educators to understand the background of all their students, it is more practical that tasks and activities are open. That is, facilitate an environment where all sociocultural backgrounds can be expressed, explored and developed while fulfilling the criteria of the curriculum.

Cultural pedagogy requires that the activities and tasks be open such that students can extend the learning of their cultural background to the classroom. In that way, the learning environment is low in threat and high in challenge, in that it gives students that security of a safe environment within which they are not limited by procedural knowledge but have the leverage to be innovative in exploring and conjecturing according to their cultural understanding of situations (Forbes, 2018).

Orchestrated immersion:

As the term suggests, orchestrated immersion requires teachers to orchestrate or design or create an environment where students can be fully immersed in the learning experience. As Caine and Caine (1989) state, "immersion as an educational process refer to the intentional envelopment of a learner in multiple, interactive, lifelike context" (p. 70). In short, it is bringing learning to life. As it relates to designing a learning experience with culture in mind, it is imperative that teachers do not make the mistake of trying to express their own interpretation of a student"s culture because in doing so they run the risk of undermining the student"s culture. Each student"s culture is unique, even within a particular culture, and can only be understood based on individual experiences. Consequently, teachers should design the learning experience in such a way that students can express the ideas from the curriculum using their own cultural understanding, thus creating a learning discourse which merges multiple life experiences into a rich and dynamic learning environment, relevant to all students.

Active processing:

Active processing refers to how the learner makes meaning of information by reflecting on their learning. This phase of brain-based learning allows learners to synthesize information in a way that is personally meaningful, providing conceptual understanding rather than merely memorizing of information. It is helping learners to think about their thinking (metacognition). Additionally, learning involves an emotional component, whereby in seeking to consolidate information, modification of knowledge can be disturbing. Active processing provides learners with the opportunity to deal with this aspect of learning. Another critical aspect of active processing that (Caine & Caine,

1989) points out is “the use of processes and procedures that avoid judgement, leaving the way open for the brain to see things in a new light” (p. 72). An important part of learning is helping students to acquire and make meaning of new knowledge. Giving students the opportunity to map new information to previous information that is embedded in their culture, is non-threatening and provide a useful foundation in assisting students to make connections. Traditional approach to teaching mathematics tends to ignore that knowledge is embedded the culture of individuals. However, an ethnomathematics approach gives students the platform to use the related cultural knowledge to acquire new knowledge. The diagram below summarizes the three interactive elements to apply brain-based learning.

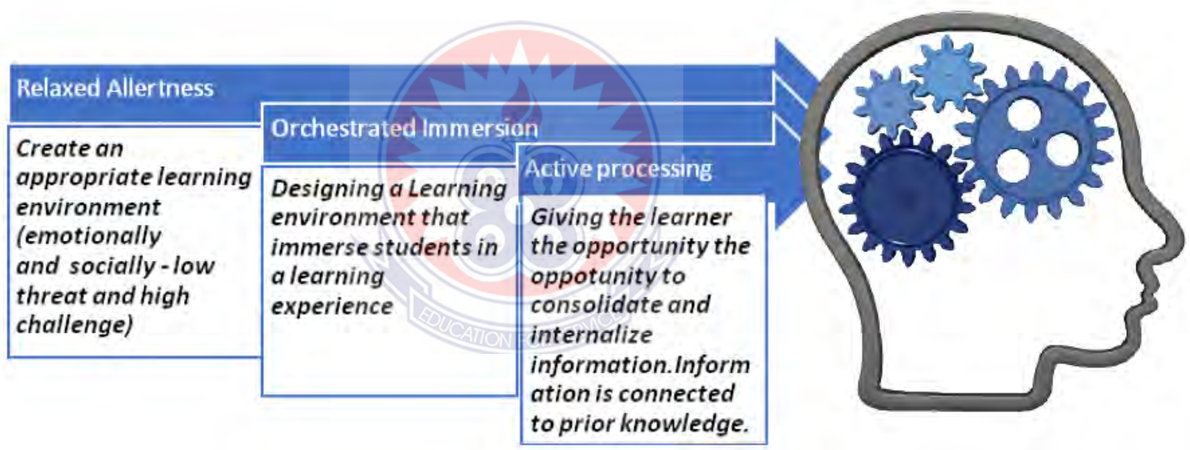


Figure 2.5: An ROA Brain-based Learning schema (Forbe, 2018)

2.4.4 The Culturally Relevance of a Mathematical Task

A mathematical task refers to whatever a teacher uses to demonstrate mathematical concepts, engage students in interaction or request students to do something, such as homework problems and classroom activities on their own or in a group (Breen & O'Shea, 2010; Margolinas, 2013). Tasks may also include any student-initiated action in response to a given situation (Margolinas, 2013).

Based on the definition above, anything assigned to students in the classroom with the intention to transmit mathematical concepts can be considered as a task. It could be activities or questions found in the textbook, online worksheets, activities found within the curriculum or teacher generated activities. However, tasks are not necessarily rich in and of themselves. Yes, a particular student may find a random task chosen from a textbook engaging, but a good teacher will not want to leave anything to chance; instead, he/she will want to make the effort to design tasks to provide meaningful learning (Forbes, 2018).

"Teachers are the most important resource for students. They are the ones who can create exciting mathematics environment, give students the positive messages they need and take any math task and make it one that piques students" curiosity and interest" (Boaler, 2016; p. 57)

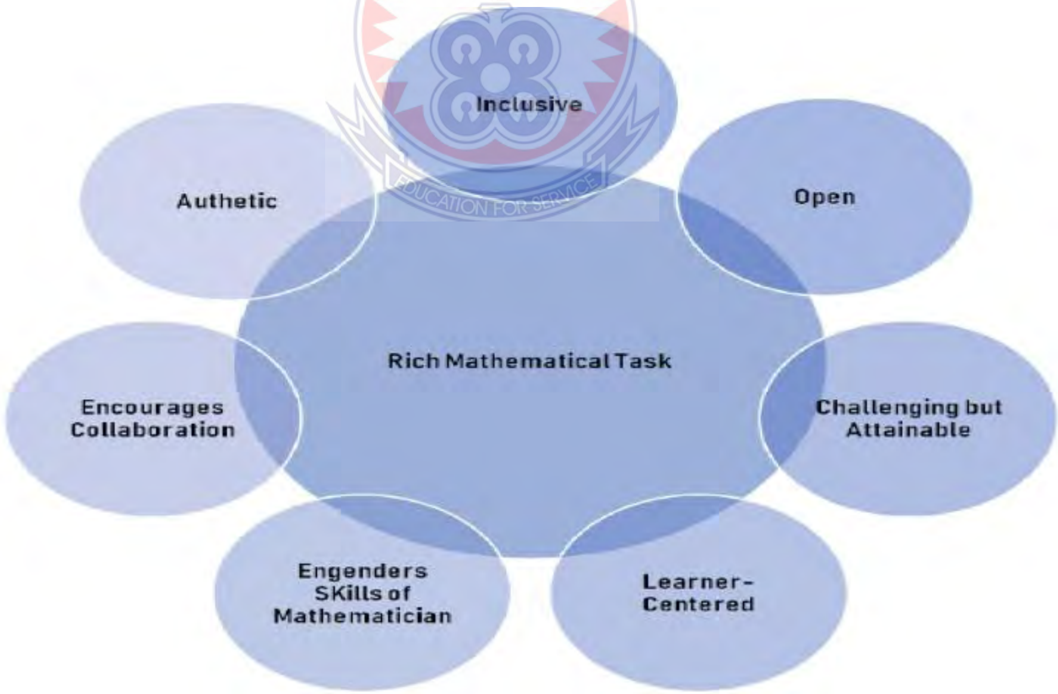


Fig 2.6: Component of culturally Rich Mathematics Tasks, (Forbes, 2018)

Mathematical task becomes rich if its revolves around seven major characteristics of inclusiveness of ethnomathematics, open to relevant solutions, challenging but attainable, learner-centred, engender skills of mathematicians, encourages collaboration and must be authentic in nature (Forbes, 2018). This study designs its various rich mathematical task in classroom interactions that seeks to connect students" understanding of mathematical concepts in formal and informal position of mathematical constructs. The Ghanaian Akan ethnomathematics is used in the form of games, activity-based lessons connecting cultural surveys that can be explored to connect selected mathematical concepts.

2.4.5 Action plan of Conceptual framework for Ethnomathematics Model for this Study

The study considered an action plan for to be used to unveil general investigation of the impact of ethnomathematical construct supporting curriculum implementation in Ghana. This conceptual framework serves as ethnomathematical model which seeks to operationalize ethnomathematics beyond existing theoretical base of it as a program (D"Ambrosio, 1989, 2012, 2018; Forbes, 2018; Harkness, Cargile, & Truhart, 2017; Oliveras, 2000; Peni, 2019; Rosa & Gavarrete, 2016).

Existing literature seeks to explain and further expatiate on the ethnomathematics as research paradigm which is emerging in mathematics philosophy. There is the need to put this idea of ethnomathematics in pedagogical action that would help address the challenges be fronting mathematics education in carrying out the role of teaching and learning of mathematics from cultural context.

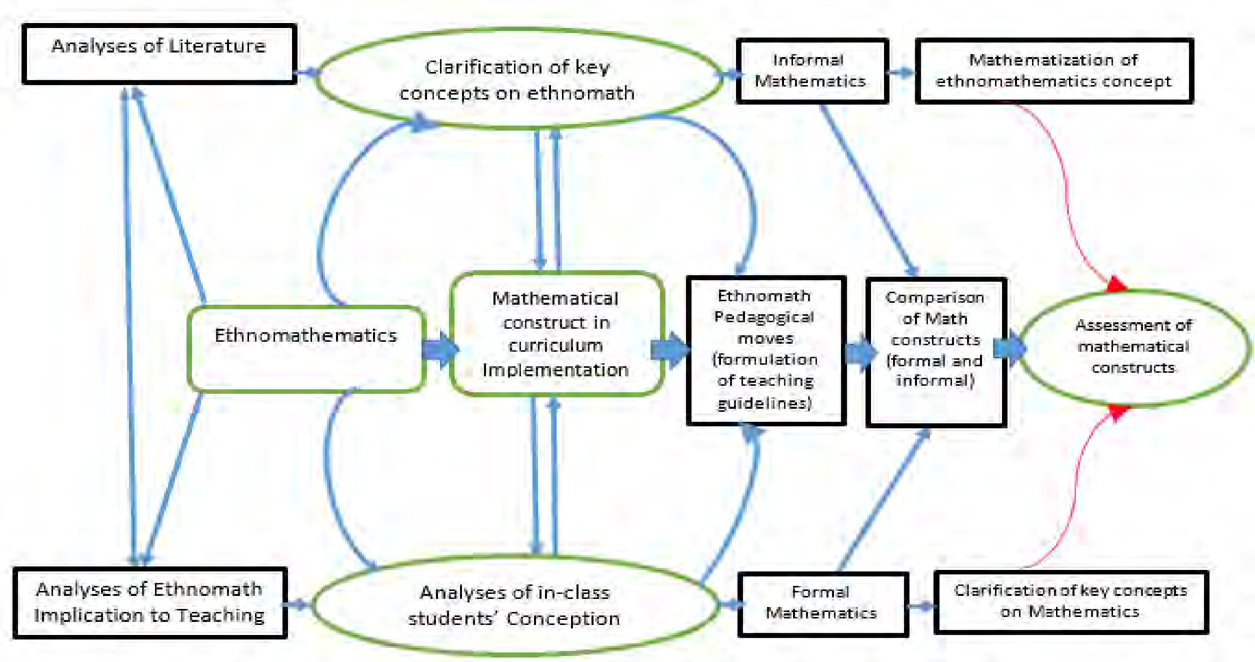


Fig 2.5: Action plan of conceptual framework for ethnomathematics model

Figure 2.7: the conceptual framework for ethnomathematics model used

Figure 2.7 above shows the conceptual framework for ethnomathematics model used for investigating the study under discussion. Following this literature review where analyses of ethnomathematics and its implication to teaching and learning of mathematics, an insight into ethnomathematics program as (D"Ambrosio, 1989; Rosa & Gavarrete, 2017; Shirley, 1986) considers it to be, is modelled into pedagogical action in practical demonstrational lessons.

Intensive literature exists on researchers" enquiry into ethnomathematics; cultural implication to the teaching and learning of mathematics. The operationalization of ethnomathematics demands a linkage of informal mathematics to the most formal one existing under the school curriculum that (Bishop, 1998) considers it as whitish and Eurocentric. To this, there is the need to operationalise ethnomathematics into pedagogical action (Peni & Baba, 2019; Wardono & Hendikawati, 2017). There is a limited consideration to the mathematization process of ethnomathematics.

Researchers" throw much interest in looking at ethnomathematics as a program, and discusses its theoretical framework. Making informal idealization of mathematical constructions to connect with the most formal one demands a lot (Budiarto et al., 2019b; Mesquita, 2017; Putra, 2018). Operationalizing ethnomathematics demands mathematics educators to mathematicise formal mathematical construct position to informal discourse. This seems a little paradoxical in which ever transition it takes. Ethnomathematical moves try to compare the informal and formal positions of mathematical ideas. The result of this is to check whether meaning teaching and learning is arrived at. This demands a critical assessment to serve as a feed-back to researchers and mathematics educators in general.

In the review of literature phase, we find a lot of clarification of key concepts on ethnomathematics done by quite a lot of researchers starting from the pioneering role of ethnomathematics philosophers (Bishop, 1997; D"Ambrosio, 1997b; Ferreira, 1989; Rosa & Orey, 2019; Shirley, 1986; Zavlavsky, 1998) and among others, just to mention a few. All clarifications are geared towards giving in-depth explanations to informal positions in mathematics. How mathematical construction are organised in an informal way. For example, the Ghanaian core mathematics syllabus in its formal structure revolves around seven (7) key scope of content in mathematics including number and numeration, plane geometry, mensuration, algebra, statistics and probability, trigonometry, vectors and transformation in a plane (GES, 2010). There is a suggestion of problem solving and applications of mathematical processes to be applied to all the topics to be treated. The study selects few concepts chosen from each of the scope and demonstrate its pedagogical actions that best fits mathematization of informal mathematics, *(GES, 2010).*

Analyses of students‟ mathematical concept recognition from formal mathematics is done in class through series of demonstrational lessons, cooperate group discussions to meet curriculum implementation procedure. This is to be done in such a way that, the lesson does not deviate from the school normal curriculum calendar. Students time would not be wasted as they interact with the various informal-to-formal mathematization processes (Putra, 2018). This in-class discussion ends at formal assessment where students would be given teacher-made-test structured from selected years of WASCE core mathematics questions under a holistic assessment procedure suggested by (Bloom, 1957) taxonomy. The purpose of assessment it to help investigate the impact of ethnomathematics pedagogies on students learning outcomes (Asmaa, 2019; Pompeu, 1992; Vithal, 1992) in its curriculum broad based. This would give the bases for the research‟s analyses and conclusion of findings hereafter.

2.5 Chapter summary

This chapter reviewed some related literature on ethnomathematics as a naturalistic philosophy where culture speaks of mathematics. The teaching of mathematics from cultural perspective were looked at. The chapter saw a discussion on theoretical, empirical and conceptual frame work surrounding ethnomathematics where pioneering authors‟ views and write-ups were reviewed. The review of these literature was done to gain an insight in what researchers have covered on ethnomathematical surveys. It is of paramount interest to consider a major gap relating to demonstrating, operationalizing, and experimenting mathematics pedagogy, teaching and learning from ethnomath point of view.

The theoretical review was done under D‟Ambrosio LMT (Literacy, Matheracy andTechnoracy) trivium model. Review of Vygoksy constructivist theory was done coupled with Realistic Mathematics Education (RME) theory. Ethnomathematics epistemology and mathematization processes connecting the formal and informal position of mathematics were reviewed in the olden and current trend of research.

The empirical framework was reviewed under Mathematical Constructs and their applications in Mathematics Education, concepts and reasoning. Implication to such constructs in teaching mathematics were also reviewed. Ethnographical View on Numeration and Number Concepts as well as the nature of formal educational systems in Ghana were also reviewed. We also discussed in review the interconnection between the formal and informal Mathematics education systems. This was done in light with the new School Curriculum and suggestive way of merging ethnomathematics to school formal systems. Since most Ghanaian communities exist in multicultural situations, a review on Multilingual effect on mathematics education was considered in review.

The conceptual framework was reviewed under the nature of informal and formal Mathematics Education (constructs). Discussion on how Realistic Mathematics Education (RME) needs to be considered in the curriculum implementation and integration into the teaching and learning of mathematics was done. The psychological means by which children learn mathematics (either formally or informally) were considered in the light of, Brain-Based Learning Model (BBLM), relaxed alertness, orchestrated immersion: active processing, the Culturally Relevance of a Mathematical Task. Finally, the Action plan of Conceptual framework for Ethnomathematics Model for this Study was discussed in the review process.

CHAPTER THREE

METHODOLOOGY

3.0 Overview

This chapter presents a plan of methods for collecting, organizing, analyzing and interpreting the obtained data so that at the end, the set of objectives of the study can be achieved. That is, the chapter sets forth and explains the research procedures and methodologies that are followed in conducting the research and in the gathering of relevant data. The chapter was subdivided into the following study areas; research design, study population, sample and sampling procedure, research instrument, source of data, mode of data collection, reliability and validity of research instruments, and the mode of data analysis as well as statistical tools for the analyses.

3.1 Research Design

Research design refers to the framework by which a research method is developed (Nesi, 2004). It is the overall techniques chosen by a researcher in developing strategic plan of addressing the problem study. The design allows the researcher to have research methods that are appropriate for addressing the research objectives and questions. Whiles research design is a plan to answer the research question, research method, according to (Farris & Van-Aken, 2019) refers to the strategy used to implement that plan.

The study adopted an exploratory mixed research design by using Quasi-experimental design. The exploratory mixed research design allowed for field exploration of Akan ethnomathematics in various informal oral education, craftiness, architectural and culturalist environment. Having explored the Akan ethnomathematics for research question one and two to establish interconnections, the study adopted a quasi-experimental approach by integrating ethnomathematics into the formal teaching and learning of school mathematics to investigate its various impact for the rest of the research questions. This design allowed the study to involve the non-random assignment of participants through a treatment (Farokhah, Arisetyawan & Jupri, 2017), as well as the application of a pretest and posttest comparison for the experimental groups respectively. Quasi-experimental design was considered because it involves the manipulation of variables through a treatment herein referred to as experimental demonstration lessons done under assumptions of ethnomathematics approach in teaching mathematics (Farokhah, Arisetyawan & Jupri, 2017).

The research sought to experiment ethnomathematics in the classroom on the teaching and learning of selected mathematical contents. The study used a mixed method research. The study demanded a situation where the researcher has a sense that scores are not telling the entire story of the impact of ethnomathematical approach on teaching and learning of some selected content of mathematics. Asking a few people about the ethnomathematical concept might help the researcher obtain a better understanding of the phenomenon under study. Extending an experimental teaching on the practicality of ethnomathematical pedagogies in the classroom gives a clearer understanding of its theoretical phenomenon. Mixed methods research, according to (Creswell, 2017), provides a "*more complete understanding*" of the research problem than either quantitative or qualitative alone. This is because, the aim of the research is to explore and investigate the effect of Akan ethnomathematical activities supporting curriculum implementation in the teaching of some selected core mathematics. The study used pretest-posttest design under quasi-experiment. The study demanded that, pre-intervention and post intervention scores should be obtained to conform to numerically measurable variables where quantitative methods would be appropriate.

There are four most preferred type of mixed methods used by most researchers: Triangulation mixed design method, Embedded mixed design method, Explanatory mixed design method and Exploration mixed design method (TEEE). The exploratory-mixed-method was chosen for the study over the others because its characteristics and assumption befits the study. This is because it involves sequential data collection, two-phase project in which the researcher considers qualitative phase first and then follow up with quantitative phase second. Hence, one phase builds on another phase intent. There is the need to first explore Ethnomathematics within settings or vicinity in which the school is situated in order to develop an instrument and to identify categories and taxonomy for follow up. Typically in exploratory mixed research design, greater emphasis is placed on the qualitative data in the study by considering explorations through collection of qualitative diary entries, analyze the data for themes, and then develop an instrument based on the themes to measure attitudes on a quantitative survey administered to a large sample before making quantitative enquiries, (Rivera & Becker, 2008).

3.1.1 Research Method

The study adopted an explorative mixed research approach (sequential) where both qualitative and quantitative methods were applied. After the field exploration, there was a qualitative analysis through field observation of Akan basic ethnomathematics evidences. This was followed by interview guide with study participants to investigate their valid identification of them based on their recognition of establishing the interconnection of ethnomathematics to school mathematical concepts learnt.

According to (Merriam, 2014) a qualitative researcher can approach an investigation from a primary interest to understand a phenomenon through interpretative, phenomenology, ethnography, grounded theory and narratives. The ethnography survey permitted the study to have a term long (one semester) stay with the selected school to experiment the ethnomathematics pedagogical integration in teaching selected topics from the Ghanaian SHS track system. The qualitative research method has some fundamental characteristics which best defines them to be unique. According to (Creswell & Poth, 2018), it takes place in a natural setting where the respondent is not so much influenced by external matters. Data is usually collected in settings where the participants experience the problem or issue that is being studied (Hatchard, 2002; Marshall & Rossman, 2006) without any interference as cited in (Armah, 2017). Here the students under study are found in their most researchable communities surrounded by their cultural settings. Culture ideally is not influenced but dynamic and adjustables. Hence, the students can give views and meanings they have about the perception of new methodology they have encountered. In this regard, the qualitative part of the mixed design was deemed appropriate. More so, the qualitative research paradigm is characterized by the use of a theoretical lens. Studies are often viewed through the lens of a theoretical framework. It may also be centered on identifying a social or political context of the issue being studied (LeCompte & Schensul, 2012; Creswell & Poth, 2018).

A qualitative paradigm under the mixed method is employed when an issue or problem needs to be explored in great depth and detail or when the researcher wants to empower a group of individuals to share their experiences. This occurs when research questions begin with "how" or "what" (Patton, 2014; Seidman, 2006). Research that takes the form of ethnography investigates in detail the implication of societal culture or social influence in knowledge, (Hancock, 1998). Qualitative research method uses an inquiry approach in which the researcher‟s central phenomenon is one key concept that need to be explored. The researcher"s investigation into operationalizing Akan Ethnomathematics in Ghanaian perspective would further asks participants broad, general questions which are open-ended and allow for in-depth responses. A collection of detailed views of participants in the form of interviews, words or images about Ethnomathematics implicative to students" adaptive environment was considered. Furthermore, analyses and codes of the data for description and themes is needed for this study. One further characteristic of qualitative aspect of mixed design approach is to interpret the meaning of the information collected through interviews and virtual images and drawing on personal reflections and past research relating to them. (Creswell, 2002, p. 58). The practicality of what (Armah, 2017) suggest from the study of Creswell (2007) is to find out from the experimental group, the extent to which the demonstrational lesson affected their new learning experience from the ethnomathematical moves. In order to have a further numerical discussion of the study variables, the study adopted the quantitative methods where numerical data was analyzed after the experimental survey is carried out.

Other research designs were considered but were eventually not carefully chosen for the purposes of this research. Even though the ethnomathematics study follow the precepts of ethnographic study as its name implies, the study did not fully follow its design since not a greater portion of the people"s culture was considered. The study adopted a full term (semester) experimental study under the green track of Ghana Education Service and demonstrated the ethnomathematics integration by considering the most immediate culture of the people in which the school is situated. Majority of teaching aid were chosen through improvisation of the traditional artifacts from the adapted culture of the people to which the school is situated.

The methodology of the study is summarized in the following flow-chart in Figure 3.1.

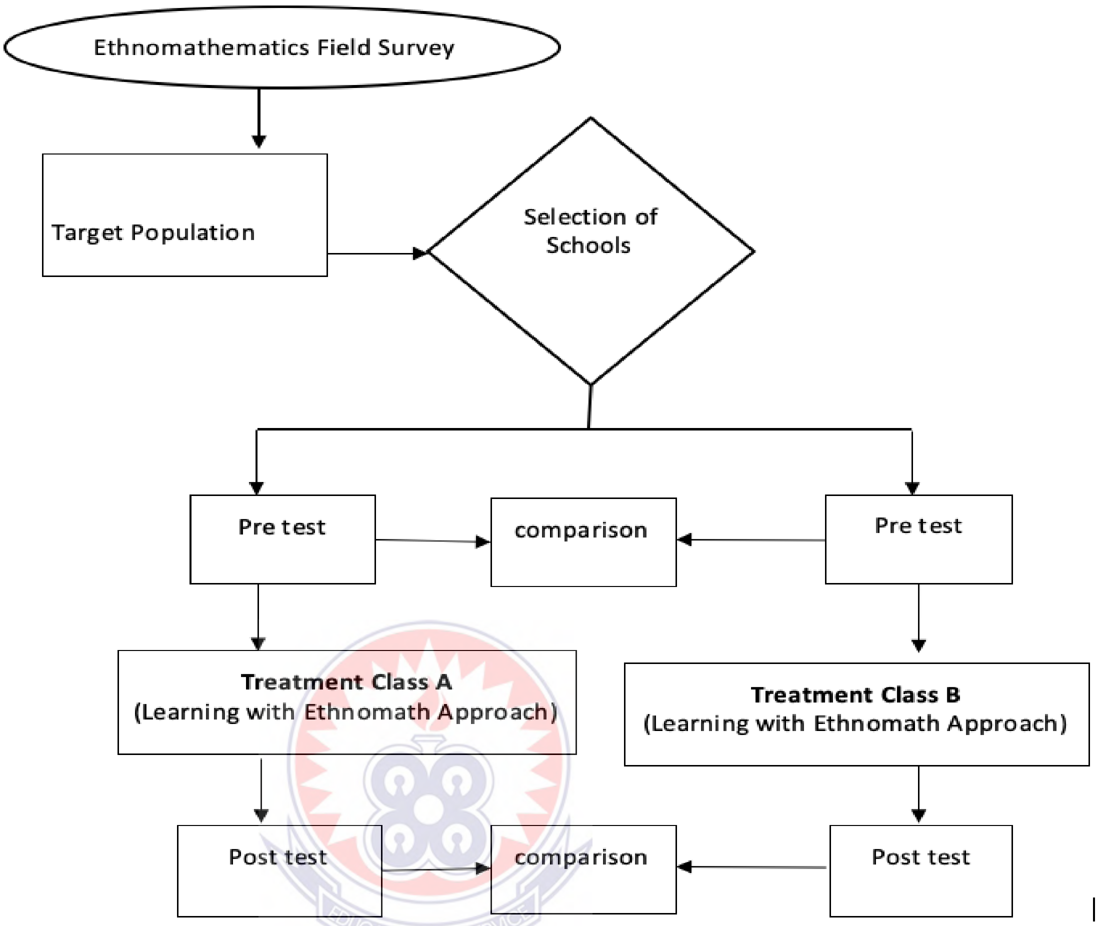


Figure 3.1: Methodological flow chart for the study

The study started with Akan ethnomathematics field survey. This field observational survey led to investigation of content analyses from informal and formal position to establish interconnection of the stream curriculum. A target population to select participants from school was done. The study organized a pre-test for two selected classes (Arts A and Arts B classes) as diagnostics evidence of students" level of understanding of the selected school mathematical concepts. A comparison was then made to establish evidence. This was followed by the quasi-experiment of ethnomathematics integration in teaching and learning in treatment class A and B chosen from the selected school. A post-test was then organized for the two classes and comparison made to establish whether there was a significant effect of the ethnomathematics under a quantitative analysis.

3.1.2 Research paradigm

A study‟s research philosophy deals with the source, nature and development of knowledge. Research philosophy is the belief about the ways in which data about a phenomenon should be collected, analysed and used (Creswell, 2017). Research philosophy can be pragmatism, positivism, realism or interpretivism. This study adopted the pragmatism research philosophy which accepts concepts to be relevant only if they support action. Pragmatism recognize the fact that there are many different ways of interpreting the ethnomathematics and undertaking research on its effects and interconnection to the teaching and learning of school mathematics. The nature of this paradigm recognizes that, no single point of view can ever give the entire picture of the existing results. There may be multiple realities associated with ethnomathematics theories and its implication to the teaching and learning of school mathematics.

3.2 The study settings

The study considered the Akan ethnomathematics, (native communities in Ghana) for the ethnomathematics survey and made application to one selected community school at Techiman. The research setting adopted by researchers refers to the place (normally areas the respondents could be located) where the data are collected for further analyses. African authors‟ and researchers are fond of appreciating what their rich culture have to offer in building a rich reconciliation of informal academic systems to the most formal one (Kurumeh, 2004; Davis & Seah, 2016; Rosa et al, 2016; Bishop, 1990; Imswatama & Lukman, 2018) within ethnomathematics study. The choice of such ethnomathematics studies considers communities with rich cultural heritage that is built upon the traditional implication of mathematics. This comes in the form of mathematical concepts and its application to indigenous technology such as buildings, cooking utensils, mats, bedroom equipment, entertainment that come in the form of games, music and dance and among others. The socio-cultural interactions surround equally, many communities in Ghana.

The study"s focused on gaining insight into ethnomathematics from Ghanaian perspective most especially among selected Akan communities. Even though, Africans share dominantly many common traditions and cultures, the study is delimited to selected Ghanaian tribal communities predominantly among the Akans whom the researcher presumed to have ethnomathematical informal education trend reflective in their culture. The implication of these to curriculum implementation by stakeholders is focused. The study considered twelve (12) Ghanaian Senior High Schools (SHS) selected respectively from within Techiman North, South and Municipal areas of Bono-East region of Ghana. The people there adopt a merging life style with the middle belt. They live in indigenous buildings whose traditional technologies are full of geometrical ethnomathematics. This selected region has a common ethnomathematics with the general Akan people which the study is focused to use as a demonstration lesson. Among singularly common element of ethnomathematics include traditional games (e.g dame, Oware, etc), numeration and counting in base ten, geometrical and conics artefact, folktales, riddles and puzzles and among others. The chosen school from the Techiman Municipal was Techiman Senior High School. The Community share regional boundary with the newly created Bono-east, Ahafo and Northern regions.

Techiman and its suburbs in the Bono-East region were selected based on its central part to all the other regions. It is believed that this region is in the central part of Ghana mediating the northern zone and the southern belt of Ghana. Techiman Senior High school was selected from its capital town, Techiman municipal. Its holds a similar characteristic to other regions considered for this study. It"s the traditional home for the Akan people when they migrated from Sahel in the ancient time to settle at Bonomanso. Some of the Akan people migrated from Bono to settle in various places of Ghana. Among some of the Akan people include the Ashantis, Akyem, Kwahu, Fanti, Nzema, Assin, Kwahu, Akuapem, Ahafo, Ahanta and among others. The peopling of Ghana is dominated by the Akans (Ansong & Philosoph, 2012). The researcher choose these schools based on their proximity, accessibility and commonness of their culture to which the ethnomathematical approach in teaching could focus.

A limitation to this study is the generalizability of ethnomathematics concepts for all Ghanaian schools and concept that is situated on multicultural systems and geographical locations peopled by students. Again, the ethnomathematical move is only piloted on some selected mathematical concepts from the SHS curriculum and not for entire generalizability. The ethnomathematics are adopted to suit the culture of these selected people alone. It is quite difficult to apply this to all mathematical concepts which is defined to conform to Eurocentric approach (Frankenstein & Powell, 1997; Michalowicz, 1997; Rowlands & Carson, 2000). The study only sought to pilot ethnomathematics pedagogical approach on selected mathematical concepts as an experimental lessons in the five selected schools from the five regions respectively. Figure 3.2 shows google map for the geographical location of study settings

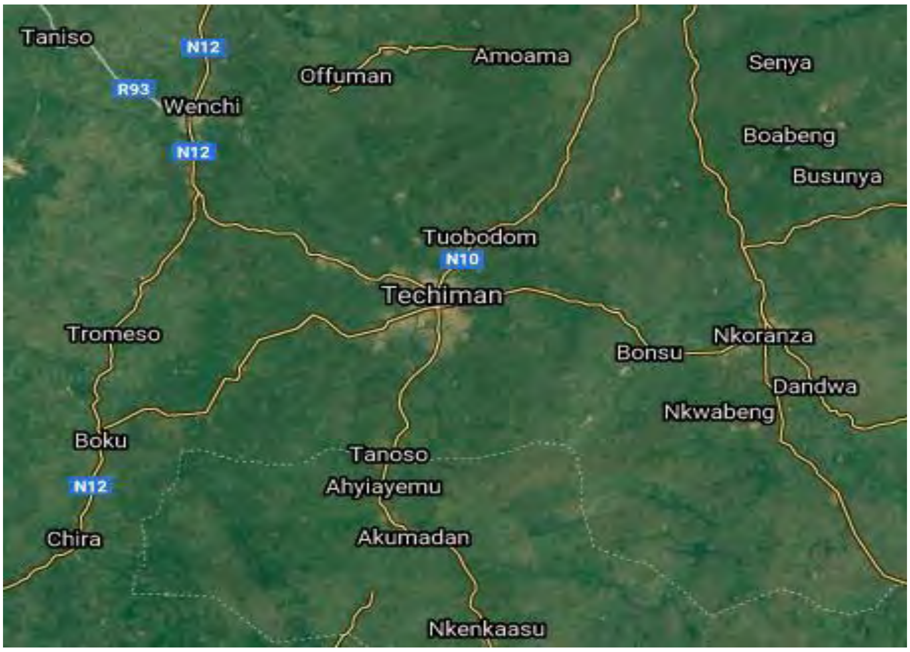


Figure 3.2: Map of geographical location of study setting (Source: Google www.googlemap.com)

3.3 The Study Population

Population is simply all the members of the group that a researcher is interested in studying a peculiar variable relative to them in the study (Widada, Herawaty, Jumri, Zulfadli, & Damara, 2019; Thomas & Ely,, 2001). The all-inclusive set of cases from which researcher sample is drawn is called the population. Since researchers neither have time nor the resources to analyse the entire population, they apply sampling technique to reduce the number of cases.

The target population constituted Mathematics tutors and Students from Techiman municipal directorate. The study target population included all mathematics teachers in Ghana Education Service (GES). The study considered the accessible population of mathematics teachers within Techiman Municipal of Bono-East region of Ghana (constituting 112 mathematics teachers) coupled with General Arts A and B students in Techiman Senior High School (constituting 340 students).

3.4 Sample and sampling technique

It is noted that sampling is the process by which the researcher selects from the population; a sub-unit of individuals who share the same characteristics (Adi, 2019). A sample is considered as a sub-set of the entire population. In quantitative methods, the higher the proportion selected within the population the better the normality assumption of the obtained score distribution due to larger proportion and central limit theorem (Merrian & Bierema, 2013). Out of an accessible population of 340 General Art students from the selected schools (Techiman SHS), a sample of 86 students was selected for the study. The researcher used a non-probabilistic sampling technique through a convenient sampling technique to select the student for the quasi-experiment of the ethnomathematics approach. The selection of the prospective school was based on convenience sampling where the research participants were selected on the basis of being accessible, immediacy, proximity and reasonably representative of the population of interest (Etikan et al., 2017). The study also considered a situation in which the school selected was not necessarily a GES grade A school where gifted students are placed. The study considered Grade B schools who were deemed to perform fairly in core mathematics. When a researcher considers a less endowed school, the perception of their abysmal performance makes an intervention seems clearer (Lassibille & Tan, 2003). This creates to some extent, a form of remediation through intervention integration of ethnomathematics. This could best be interpreted from its natural ethnographic setting (Merrian & Bierema, 2013).

The selection of the mathematics teachers to investigate their awareness and perception of ethnomathematics integration of their curriculum implementations was done under probabilistic approach. A census sampling technique was adopted for the selection where all the participants were taken into consideration for the study. Table

3.1 and 3.2 show the population of teachers selected from the respective schools in Techiman municipality. Table 3.1 and 3.2 gives the sample for all teachers selected from the cluster schools within Techiman and its suburb and student samples respectively.

Table 3.1: Target population and sample proportions of Mathematics Educators within Techiman Suburbs

Sampled School	School Category	No of teachers	Percentages (%)	Cumulative Proportion
1	B	16	14.29	14.29
2	A	11	9.82	24.11
3	C	7	6.25	30.36
4	C	8	7.14	37.5
5	D	9	8.04	45.54
6	D	9	8.04	53.58
7	D	13	11.61	65.19
8	D	5	4.46	69.65
9	D	10	8.93	78.58
10	D	7	6.25	84.83
11	C	12	10.71	95.54
12	D	5	4.46	100
TOTALS		**112**		

Table 3.1 gives the sample population of Mathematics teachers with sample proportion within the cluster of schools within Techiman and its suburbs. In all, there were 112 mathematics teachers considered for the study from about 12 secondary schools. These schools were graded between GES category A-D. The sampled students from the chosen demonstration school is given in Table 3.2.

Table 3.2: Sampled students based on gender proportion within selected school.

Gender	Arts A	Arts B	TOTALS
Males	22	34	56(65.9%)
Females	16	14	30(34.1%)
TOTALS	38(44.2%)	48(55.8%)	86 **(100)**

From Table 3.2, the sample of Arts A and B classes considered for the study is given. Two of the General Arts classes A and B were considered there were 38 students in Art A constituting 44.2%. There were 48 students constituting 55.8% proportion. 56 (65.9%) were males whiles 30 constituting 34.1% proportion were females. In all, 86 students were considered for the quasi-experimental study with the ethnomathematics approach of teaching.

In quantitative methods, the higher proportion selected within the population is expected to give a fairer normality assumption of the obtained score distribution due to larger proportion and central limit theorem (Agresti, 2007; Plano Clark & Creswell, 2015). The study adopted a non-probabilistic sampling technique by considering convenience sampling. Convenience sampling is a form of non-probabilistic sampling technique which involves selecting participants based on the fact that they are often readily and easily available. Convenience sampling often helps to overcome many of the limitations associated with research, (Etikan et al., 2017). For example, using schools within the most closest bound of the research as part of sample is easier than targeting unknown individuals or schools located from afar (Hamed, 2017). Convenience sampling has major characteristics of easily accessibility, proximity, and closeness of respondents, instruments and tools that would make data collection and analyses more proximate. It is based on this that the researcher chose Techiman Senior high Arts students. The researcher choice of General Art students is due to the general perception of their weak performance in mathematics.

3.5 Data Collection Methods and Instruments

The sources of data for the study were from primary source. Primary data source is a source from which first hand data is collected, either with the use of observation, questionnaire guide, interview or other mode of data collection tools

(Merrian & Bierema, 2019). Categorical data are normally gained from primary source. When the researcher goes to the grassroots to collect factual information, the results obtained normally ensure credible , reliable and dependable results (Agresti, 2007).

In research, data collection methods are seen as approaches developed by a researcher to achieve their stated objectives when carrying out a research study (Edekin, 2016). It is the means by which a researcher collect data surrounding his/her variable of interest for further analyses and interpretation. In this study, the researcher used the following methods to collect data for the study:

1. Observation Guide (Unstructured)
2. Interview guide,
3. Focus group Discussion Guide (FDG)
4. Questionnaire survey
5. Test.

The study explored through observation and interview guide, the Akan ethnomathematics in various informal oral education, craftiness, architectural and culturalist environment. The study also adopted a quasi-experimental approach by integrating ethnomathematics into the formal teaching and learning of school mathematics as experimental or demonstrational teaching approach to investigate its impact. Quantitative data for the purpose of this study was collected from the scholastic records of students" pretest and post-test scores. The researcher then used questionnaire and interview guide to probe further, students and teachers" perception of ethnomathematics integration into teaching and learning of mathematics with respect to effectiveness and usefulness, interest and motivation as were as challenges associated with it.

3.5.1 Observation Guide

An unstructured observation guide (see Appendix D) was used to collect data for research question one and two. In order to have a second look at the ethnographic phenomenal response, a qualitative data analyses were also considered for the study. This necessitated the use of observational techniques from the communities" settings. The culture of the Akan people was given an in-depth exploration of the mathematical elements that can support the teaching of mathematical concepts in the school curriculum. This was to help guide experimental teaching with the ethnomathematics approach and strategies adopted for the selected topics. Teachers" general view of this ethnomathematical philosophy of teaching and their awareness as well as perceived interconnections to school mathematics were also surveyed based on their observations of the ethnomathematics found within their catchment areas. Where necessary, photographs and pictures of scenes were taken for qualitative, content and contextual analyses. This instrument was based on the researchers own ethnographic observation used to discuss researcher questions one and two respectively.

The observational guide used for the field data exploration to ascertain some basic Akan ethnomathematics were guided by 10 explorative questions for the survey as seen from Appendix D . The guide was used to find information surrounding Akan basic and fundamental ethnomathematics existing to support the teaching of school mathematics. It helped in the exploration process to assist the content analyses of existing documents in the formal mathematics curriculum (such as syllabus) that interconnect the informal Akan ethnomathematics

3.5.2 Interviews Guide

According to (Abawi, 2013), interviews consist of collecting data by asking respondents questions about your research goals. Through interview, data can be collected by listening to individuals, recording, filming their responses, or a combination of methods. There are four types of interview methods: Structured interview, Semi-structured interview, In-depth interview, and Focused group discussion.

In structured interviews the questions as well as their order is already scheduled. Your additional intervention consists of giving more explanation to clarify your question (if needed), and to ask your respondent to provide more explanation if the answer they provide is vague (Edekin, 2016). There is also a Semi-structured interviews a researcher may offer. This includes a number of planned questions, but the interviewer has more freedom to modify the wording and order of questions.

The study collected complete information with greater understanding to the ethnomathematics. Interview has the characteristics of allowing for more control over the order and flow of questions as compared to questionnaires, allowing the study to have higher response rates of the participant (Abawi, 2013). The study adopted some focus group (craftsmen) discussion on the way some of the cultural artifacts are made and their knowledge of informal mathematics application as a basis of their creativity. Semi-structured interview was given to both mathematics focus group and student participants sampled for the study (see Appendix I).

3.5.3 Focus group Discussion Guide (FDG)

Focus group is a structured discussion with the purpose of stimulating conversation around a specific topic. Focus group discussion is led by a facilitator who poses questions and the participants give their thoughts and opinions (Abawi, 2013). Focus group discussion gives us the possibility to cross check one individual‟s opinion with other opinions gathered. In a group situation, members tend to be more open and the dynamics within the group and interaction can enrich the quality and quantity of information needed by the researcher. In focus groups the participants are invited to talk about their views, attitudes and beliefs in relation to a particular subject (how indigenous culture and social life of the people portray mathematical knowledge and usage or application), concept (mathematical construct) or idea (ethnomathematics) (Canals, 2017). This might include structured questions to guide the informants on talking about certain aspects to be considered for each subject or sub-topic. The type of data that can be obtained in this way include opinions, assertions about beliefs, expressions of agreement or disagreement with other participants, and processes in which individual or group (cultural) identities are built.

In the FGD, the study considered within the research setting, the opinions of craftsmen and few users of some cultural element believed to possess ethnomathematics. Their opinions on what practices within the community"s socio-cultural life portrays informal knowledge in mathematics were investigated. This gave the study exploratory evidence by which the experimental lesson and further interview and questionnaires were guided and structured respectively.

The Focus group Discussion Guide (FDG) had thirteen (13) interactive questions that helped in the collection of further information to clarify the field exploration through observation. It assisted in the analyses of research questions one and two.

3.5.4 Questionnaires Survey

According to Hinneh-Kusi (2012), questionnaire is a research instrument that contains a list of research or survey questions asked to respondents. A questionnaire which was invented by Sir Francis Galton is also seen as a data collection instrument that is consistent with series of questions and other prompts for the purpose of gathering information from respondents (Abawi, 2013). The researcher was of the view that questionnaires are mostly used by qualitative and quantitative researchers to help in data collection by throwing questions to respondents based on the opinion they have about a phenomenon. It could also play essential role in quantitative research if the researcher wants to collect data appropriately, make data comparable and amendable when secondary data are mostly unavailable (Trigueros, 2018).

According to Sekaran and Bougie, (2016), questionnaire is an efficient data collection instrument if only the researcher knows exactly what is required and how to measure the interested variables. Forty-four (44) questionnaire items were designed to suit the research objectives and which were administered to the respondents. The questionnaires were organized into three (3) sections A-C. Each section seeks to find answers to the research questions defined for the study. The sections are organized as themes on the basis of the study objectives. Questionnaire is one of the best instruments procedures in collecting data for qualitative and quantitative research designs respectively. Questionnaire, when widely used for collecting data in educational research, and if developed to answer questions is very effective in securing factual information about practice and conditions at which the respondents are presumed to have knowledge and for inquiring into the opinions and attitudes of the subject under study (Hulst et al., 2015).

There were two set of questionnaires guide. One set for teachers (see Appendix G) and another set for students (see Appendix H). Each of these respective questionnaires were put into six sections labelled A, B, C, D and E. section A considered demographic information of respondent teachers and students respectively. The rest of the sections also considered the themes for each of the respective research questions. Teachers" questionnaire had 18 question items. Sections B-E of the teachers questionnaires were put into themes aligned with research questions four to six set for the study.

Similarly, students were given questionnaires guide after the demonstrational lessons to investigate their perceived impact with respect to usefulness and effectiveness as well as interest and motivation received from their ethnomathematics lessons. Students questionnaires had five section A-E. section A of students questionnaires demanded their demographic information. The other sections B-E were put into 10 broad Likert Scale themes surrounding the study"s research questions three to four

3.5.5 Test scores

In exploratory mixed design research methods, the researcher considers quantitative data collection and analyses after his qualitative exploration (Creswell & Poth, 2018). Test scores is one of the most efficient quantitative data collection instruments. Test scores of students is normally suitable for quantitative data that demands the researcher to make in-depth analyses using descriptive and inferential statistical analyses. It has the most suitability of testing hypothesis under several inferential statistical assumptions (Edekin, 2016).

The test scores of students could be seen from *Appendix M.* The study organized pre-test (*see Appendix E*) and post-test (*see Appendix F*) preceding and proceeding the ethnomathematics approach of teaching school mathematics for the two sample classes (Arts A and Arts B) of the selected school. Students were put into two (2) classes of General Art „A" and „B" experimental group to study the selected mathematical concept for a full semester under the Green-Track system of the selected School. In all, structured questions were set with marking rubrics for the selected topic. The selected mathematical concepts were taught from the Ghanaian core mathematics syllabus (GES, 2010).

The section of the test items considered students‟ knowledge on selected topics under the curriculum strands. The main themes of the school mathematics curriculum (syllabus) were considered. The study adopted short answers to easy-type test items. This was to drill students‟ cognition of the selected topics and the extent to which application and evaluation of the ethnomathematics and mathematical constructs has been conceptualized. Students were asked to provide their own answers and justify reason for their choice of answers. Instead of focusing on computations and procedures, the test items also focused on computational reasoning on application of their own cultural and social ethnomathematics thinking that could be liaised with the formal cognition of the mathematical construct binding the solution to each given question. The respective pre-test and post-test question sets had 20 question items each spread over selected concepts from the formal and informal mathematical standards.

All the cognitive, effective and psychomotor domains were considered in crafting the test items. Students obtained scores were tallied in Microsoft excel version 2016. Marked scores of students constituted part of the data set which were used to make comparative study for the selected experimental classes A and B for assessing the impact of ethnomathematical moves on the academic performances of students (see Appendices E and F). The analyses were subjected to significant mean test difference of students obtained scores under quantitative exploration.

3.6 Validity

The principles underlying naturalistic and/or qualitative research are based on the fact that validity is a matter of trustworthiness, utility and dependability that the evaluator and the different stakeholders place into it (Zohrabi, 2013). The researcher and research respondents‟ attempted building validity into the different phases of the research from data collection through to data analysis and interpretation (Merriam, 2014). To some extent, validity is concerned with whether our research is believable and true and whether it is evaluating what it is supposed to measure or purports to evaluate. In this regard Burns (1999, p. 160) stresses that "validity is an essential criterion for evaluating the quality and acceptability of research."

Generally, researchers use different instruments to collect data. Therefore, the quality of these instruments is very critical in bringing out an expected results that is consistent and valid. This is because "the conclusions researchers draw is based on the information they obtain using these instruments" (Fraenkel & Wallen, 2003, p. 158). On the whole, the following miscellaneous procedures were used to establish credible, trustworthiness and dependability of the ethnomathematics findings.

3.6.1 Content Validity:

Content validity is related to validity type in which diverse elements, skills and behaviors are sufficiently and efficiently measured by the instrument (Zohrabi, 2013). To do this, the research instruments and the data were given a review by the experts in the field of research and mathematics examiners. The content of the test instrument were given a face validation by the supervisor who is expert in mathematics education content and curriculum. Colleagues‟ examiners to West African Examination Council (WAEC) assisted in cross-checking the content of the questions for the test. The test items were also subjected to Bloom taxonomy of instructional learning which seek to assess students holistically (Bloom, 1957). To do this table of specification were outlined for the demonstrational lessons which helped in the content diagnosis of the mathematical concepts considered for the teaching. The researcher also considered the profile dimension suggested by the Ghana Education Service syllabus for Core-

Mathematics (GES, 2010). Based on the reviewers (examiners) comments on the questions, the unclear and obscure questions were revised and the complex items reworded. Also, the ineffective and nonfunctioning questions were discarded altogether. These face validations ensured more credible content validity of the test instrument used for all the ethnomathematics demonstrational lessons.

3.6.2 Internal Validity

Internal validity is concerned with the congruence of the research findings with the reality (Bolarinwa, 2015; Zohrabi, 2013). Also, it deals with the degree to which the study observes and measures what is supposed to be measured. On the whole, to boost the internal validity of the research data and instruments, the researcher might apply the following six methods recommended by (Mertens, 2015) as cited by (Zohrabi, 2013): triangulation, member checks, long-term observation at research site, peer examination, participatory or collaborative modes of research and researcher‟s bias. In order to ensure internal validity of the research instruments, the study considered these six models of internal consistency through the following discussions:

1- *Triangulation*: In order to support the validity of the evaluation data and findings, the study considered a collection of data through several sources: observation of the community settings and cultural elements, followed by focus group discussions, test instruments, questionnaires, interviews and classroom observations. Gathering data through one technique can be questionable, biased and weak, (Bolarinwa, 2015). However, collecting information from a variety of sources and with a variety of techniques can confirm findings. Through triangulation we can gain qualitative and quantitative data in order to validate our findings. Since the study used mixed exploratory design methods, divergent instruments were used through triangulation processes to ensure internal validity.

2- *Member checks*: Through member checks the results and interpretations of scores used for the data were taken back to the participants (students) in order to be confirmed and validated. The class captains played a contributive role in ensuring that every student marked script is given out and confirmed. In this way the plausibility and truthfulness of the information can be recognized and supported.

3- *Long-term observation*: Repeated observations over an extended period of time can naturally enhance the validity of research data and findings. Zohrabi, (2013) suggested that the researcher should try to visit different classes in order to obtain the intended information. The observation continues as long as the saturation point is achieved. Its bu this virtue that the study considered five different schools with different classes to help validate internal consistency of data collection and interpretation based on the normality assumption.

4- *Peer examination*: In peer examination process the research data and findings are reviewed and commented on by several nonparticipants in the field. As already explained, there were several content reviews of the test instrument and questionnaire by the peers and colleagues for the admittance of several critiques which led to final corrections and data collections.

5- *Participatory or collaborative modes of research*: This means that the researcher should try to involve most of the participants in all phases of inquiry. The purpose "is to arrive at evaluation conclusions as a result of a consensus among persons from different perspectives in relation to the program" (Lynch, 1996, p. 62). Clearly, it is very difficult for the researcher to conduct a study single-handedly. But sharing ideas with different students, learners, teachers and instructors helped strengthen the research findings and interpretations. The researcher tried to involve the students, colleagues in the mathematics department as well as language instructors who gave a proof reading of the content to check on the correct grammar usage. Again, subject instructors and program staff were involved in the different phases of the study in order to enhance the validity of the research. Their varied ideas and views were constructive and useful in ensuring the internal validity of the study.

6- *Researcher"s bias*: In as much as the researcher want to ensure a more candid, trustworthy and dependent results, the choice of instruments was professionally administered, samples, interpreted and analyses devoid of biasedness, insufficiency and inconsistency. Ethical consideration was truly assured throughout the study.

3.6.3 Utility Criterion

In addition to the above-mentioned six benchmarks of checking and backing to ensure the validity process, the researcher added the utility criterion to ensure further validation. Lynch (1996, p. 63) asserts that “Utility refers to the degree of usefulness the evaluation findings have for administrators, managers and other stakeholders.” This criterion intends to inquire whether or not the research works. That is, utility criterion asks whether the evaluation endeavor generates enough information for the decision-makers with regard to the effectiveness and appropriateness of the program.

Clearly, the findings of this study is useful to Ministry of Education in Ghana, National Council for Curriculum and Assessment (NaCCA, 2019; CRDD, 2010) of Ghana Education service, mathematics educators, and students to appreciate the need to consider and strengthen the ethnomathematics to facilitate the formal instruction of teaching mathematical concepts. The researcher made appropriate recommendations for further research and whosesoever the study is purported to be utilized. Hence, utility criterion for validation of this research is guaranteed.

3.6.4 External Validity

In as much as internal validity is paramount in ensuring credibility of research instruments in measuring what it is supposed to measure, the researcher should also consider the external validity to his or her research. External validity is concerned with the applicability of the findings to other settings or with other subjects. As Burns (1999, p. 160) notes "How generalizable to the other contexts or subjects is our research." It might depend on the underlying similarities between researchers‟ context and other contexts that seems to be connected or perhaps similar and relevant. Nunan, Donovan & Jakovljevic, (1999, p. 17) puts emphasis on the research design and states that "Is the research design such that we can generalize beyond the subjects under investigation to a wider population? To (Armah, 2017; Okori & Jerry, 2017), the external validity of research is the generalizability attributed to the study. That is evidence that point to the fact that others can point to its application to other areas and fields which is deemed appropriate.

In so far as the study could be seen by any researcher to be helpful in contributing to literature and helping other stakeholders in ensuring smooth mathematics education through naturalistic view of ethnomathematics, the study is deem to be externally valid.

3.7 Reliability of Instruments

Reliability of the instruments was obtained by using the test re-test reliability. Fraenkel and Wallen (1996) argue that for most educational research, stability of scores over a period of two months is usually viewed as sufficient evidence of test - retest reliability. Therefore, the researcher pre-tested and retested the instruments on a small number of participants in an interval of two weeks for a pilot data analyses. The researcher computed the reliability for the quantitative data of students‟ scores under the Cronbach alpha using Statistical Package for Social Sciences (SPSS) software. The coded response in the SPSS yielded a reliability coefficient of 0.914 showing a very strong Cronbach's Alpha coefficient, (Zohrabi, 2013)

Table 3.3: Case Processing Summary for Cronbach's Alpha for instrument

		N	%	Cronbach's Alpha	N of Items
Case	Valid	95	93.1	.914	82
	Excluded[a]	7	6.9		
	Total	**102**	**100.0**		

a. Listwise deletion based on all variables in the procedure.

Table 3.3 reveals the case processing summary for Cronbach"s alpha. A Cronbach"s Alpha of 0.914 was estimated. This shows a very high reliability evidence for the observed scores obtained by the students in the various test items administered.

Internal and external validity according to Guba and Lincoln, (1994) seeks to ensure that research work measures what it intends to measure. According to (Merriam, 2014), it asks the question, "How congruent are the findings of a study with reality"? (p. 53). The researcher made sure that internal and external validity were consistently taken care of. The credibility criterion associated with this includes establishing that the findings of a qualitative research are believable from the point of view of the participants in the mixed research study. From this point of view, qualitative research is meant to provide a description or an understanding of the phenomena of interest from the participant's point of view. The participants are the only ones who can legitimately judge whether the results are credible (McAninch, 2015), meanwhile, an estimate of the reliability coefficient was estimated from the SPSS as 0.914. This is evident in the result and response obtained from the population. In ensuring credibility, researchers try to establish the fact that a true picture of the phenomenon under study is presented, (Shenton, 2004). This addresses the issue of internal validity as in a quantitative study.

Before information was obtained from participants of this study, they were briefed on the purpose of the study and also made to feel at ease. They were made to understand that results were not going to be part of their terminal report. They were also not restricted to any time duration in the test to ensure they had enough time to think and express themselves. Similarly, during the questionnaire online survey, participants were given enough time to express themselves until the researcher realized they had exhausted all they knew about the topics under study. Opportunity was given to students to effect any change of response if the need arises. Questionnaires were given to the HODs of the respective schools and scheduled its collections within two weeks where teachers would have ample time to study the questions and given a credible response.

Closely connected to reliability is the need to consider Validity issues. Validity explains how well the collected data covers the actual area of investigation (Ghauri & Gronhaug, 2020). Validity basically means "measure what is intended to be measured" (Field, 2016). One of the main requirements of any research process is to consider the reliability of the data and findings. Reliability deals with the consistency, dependability and replicability of "the results obtained from a piece of research" (Nunan, 1999, p. 14). According to (Zohrabi, 2013), obtaining the similar reliability results in quantitative research is rather more candid and straightforward because the data are in numerical form other than in qualitative methods. It is because the data are in narrative form making it subjective in nature.

Taherdoost (2016) point out that instead of obtaining the same results, it is better to think about the dependability and consistency of the data for which according to (Armah, 2017) considers it as the extent to which the instrument is reliable. In this case, the purpose is not to attain the same results but rather to agree that based on the data collection processes the findings and results are consistent and dependable. (Merriam, 2008) believes that "the human instrument can become more reliable through training and practice." (Yui, 2016) suggest that the dependability of the results can be ensured through the use of three techniques: the investigator"s position, triangulation and audit trial.

1- *The investigator"s position*: In order to increase the study"s reliability, the researcher needs to explain unambiguously the different processes, methods and phases of the inquiry. It is in the light of this that the researcher adopted self-positioned teaching on the use of ethnomathematics approach. Therefore, the researcher should elaborate on every aspect of the study.

2- *Triangulation.* This refers to the way by which the research collects varied types of data through different sources to enhance the reliability of the data and the results, (Yui, 2016). In this way the reproduction of the researcher"s choice of different procedures such as questionnaires, interviews and classroom observations to collect data enhanced the reliability coefficient.

3- *Audit trial:* reliability of this study is fulfilled through audit trial. In order to fulfill this procedure, the researcher described in detail how the data are collected, how they are analyzed, how different themes are derived and how the results are obtained (Farris & Van Aken, 2019). Therefore, this detailed procedure of audit trial replicates the research and contribute to its reliability.

3.7.1 External Reliability

On the whole, external reliability is concerned with the replication of the study. To (Bitsch, 2005), external reliability referred to as transferability which "describes the extent to which results of a qualitative study can be transferred to other settings with different respondents" as cited by (Armah, 2017). It represents how the conclusions of the research may be related to other circumstances similar to the study carried out.

It is believed that the external reliability of the research can be increased if the inquirer pays heed to five (5) important aspects of the inquiry (LeCompte & Goetz, 1982; Nunan, 1999). These include the status of the researcher, the choice of informants, the social situations and conditions, the analytic constructs and premises and the methods of data collection and analysis used for the research. This study is justified by its external reliability based on the five characteristics outline. The researcher‟s social position with regard to the participants of the study was clarified and the researcher played his role as a facilitator of the ethnomathematics move only.

For the choice of informants, the researcher chose students for his experimental survey based on the evidence from focus groups identified from the selected communities. Therefore, if any independent inquirer prefers to replicate the study, it could be done equitably easily, all things being equal, with similar results. The social situations and conditions necessitated the need for the research to be conducted in an academic situation where students were taught selected topics in an academic setting for a semester. All the learners were given equal opportunity to study the given mathematical concepts.

The fourth external reliability feature the study affirm was to look for the analytic constructs and premises. The main terms within ethnomathematics perspective, mathematical constructs, definitions, units of analysis and premises should be delineated and their underlying assumptions elaborated on explicitly. Therefore, the identification and description of constructs and premises can ease the process of replication and consequently enhance reliability.

Lastly, methods of data collection and analysis is a factor in enhancing external reliability. The different procedures of collecting data was crafted well and explicitly explained evidences that call for the instrument. The main methods of gathering information in mixed method research are observations followed by focus group, interviews, questionnaires, and students test scores. The quantitative data are analyzed through descriptive statistics and qualitative data by means of descriptive and thematic interpretations considered for the ethnomathematics study.

3.7.2 Internal Reliability

Internal reliability deals with the consistency of collecting, analyzing and interpreting the data (Zohrabi, 2013). To some researchers, it refers to the credibility attributed to internal consistency of the data organization, collection and analyses (Armah, 2017). The internal reliability might be obtained when an independent researcher on reanalyzing the information comes to the similar findings as the original researcher. Burns (1999, p. 21) asserts that "Would the same results be obtained by other researchers using the same analysis?" In the current study, in order to lookout against threats to internal reliability, the researcher has used the four (4) basic strategic characteristics recommended by (LeCompte and Goetz, 1982) and expounded on by Nunan (1999). These are: the use of low inference descriptors, multiple researchers/participant researchers, peer examination and mechanically recorded data. The study followed these four recommendations to mechanize the internal reliability.

Low inference descriptors: Low inference descriptors are "easily observable and can be readily quantified (i.e. counted or measured)" (Richards & Schmidt, 2013, p. 239). An example of this comes in the form of asking factual questions that could be counted and measured. On the other hand, high inference descriptors are categories of behavior which cannot be observed directly but which has to be inferred. For example, it is difficult to observe and measure the students‟ motivation and interest compared to the number of times students answer questions. These intricate descriptions and explanations boost the internal reliability and any independent observer can observe and replicate them more easily. To achieve this the researcher integrated both close and opens ended questions in a formal and informal assessment procedures and forms for participants to follow, (see appendix B). Issues of students‟ motivation were ensured in different forms; through extrinsic and intrinsic motivations. Although not measurable, but it is evidential in the ethnomathematics tools and resourceful teachings that enhances students‟ interest in the mathematics lesson. Any teaching model that depends on improvisation and instructional technologies motivate students to perform better (Aritsya Imswatama & Lukman, 2018).

Multiple participant response: As Nunan (1999, p. 60) acknowledges "In much research this is not feasible, because a research team consisting of several members can be extremely expensive." However, he suggests that the researcher can ask the experienced participants to help him/her verify and confirm in the data collection, analysis and interpretations. Therefore, the researcher can involve two or more participants in the analysis, interpretation and validating conclusions. Based on this, the study involved students in recording and sharing students marked scripts. Students were asked whether they are pleased with the performance and whether also, the obtained marks reflect their personal average achievement. Class captains were given the chance to appraise the class performance. Participants were satisfied with their results (performance) in the various test administration.

Peer examination: Lecompte and Goetz (1982) this method can be implemented through applying and utilizing other researchers" findings. According to (Zann, 2017) the investigator can use other researchers" results and conclusions in his/her report. Thus, the researcher can utilize some relevant studies in his/her research in order to enhance the internal reliability. Peer examination is where the researcher uses his/her findings to make connection to what other similar researchers have found. The study would equally make inference to literature and reconcile findings to what other researchers have done on ethnomathematics studies.

Mechanically recorded data: The interviews can be recorded and preserved, therefore, the reanalysis or the replication of the data can be rather easily implemented by any independent investigator. This procedure can increase the internal reliability of the data and findings. The study took care of proper recording of results and data entry of responses. The collected data were coded into Statistical Package for Social Sciences (SPSS).

3.8 Ethical consideration

Ethical consideration refers to the extent to which the researcher respects the world view of the respondents as well as social norms of the people which constitute the population domain. The issue of protecting participants" private data in research projects is very important, especially when working with respondents and young people in disadvantaged or socio-cultural complex situations (Canals, 2017). In all the communities the researcher went, provision was made to obtain consent from all the participants and their legal guardians from the schools and the communities. This were done by sending an explanatory and request letter outlining most especially to the headmaster of the selected school, the objectives of the thesis and the rationale behind their chosen school for the demonstrations lesson (see appendix E). It is also important to explain how the data will be processed and the scope of their public disclosure (Canals, 2017).

The researcher was very professional in carrying out the research in an altitude of sincerity. Being confidant to the respondents ensured sanity and ethical reflection. For example, the marked scripts were shared to students individually by mentioning names of student participants to come for their scripts individually. Confirmation of clarifications and misunderstandings were done privately. Students who were absent at the time of sharing scripts were kept for them either by the researcher or the Head of Department (HOD"s). This ensured that student"s performance is not ridiculed by their mates, especially if they do not perform well.

In addition, concern form was designed for the study participants to fill. Issues surrounding ethical consideration relating to the demonstrational lesson participation were spelt out. Students filled and signed the forms to show their interest to participate in the demonstration lesson.

3.9 Mode of data collection

Accurate and systematic data collection is critical to conducting scientific research. Data collection allows us to collect information that we want to collect about our study variables. Depending on research type, methods of data collection include: documents review, observation, questioning, measuring, or a combination of different methods (Abawi, 2013).

The researcher explored Akan communities through observation of their cultural activities that is deemed to possess ethnomathematics. Some pictures were taken for contextual analyses alongside content analyses to deduce interconnection between Akan ethnomathematics and formal curriculum standard from the syllabus.

After the exploration, series of mathematics lessons wre taught in two experimental classes labelled A and B classes respectively. Students were given teacher-made-test internally and end of demonstration (experimental) lesson test. Questions were set from the scheme of work for the selected mathematical concepts prepared by mathematics teachers of the chosen cohort school. Topics for students to do sit-down exams were edited by the HOD. Students‟ scripts were marked with the marking rubrics for the selected school in the region. The obtained marks were then gathered, coded into Microsoft Excel and SPSS software for the analyses through quantitative scale.

Since the design uses predominantly, a mixed design, a qualitative data gathering was done through observations, focus group discussions, interviews and questionnaires answered by contacted students and teachers. Both students and teachers were given questionnaires guide to answer based on their perceived effect of ethnomathematics integration in the mathematics teaching and learning process. Few who were difficult to contact were given through online submission either by mail or WhatsApp. Their responses were collected to form the bases of the study‟s data analyses.

3.10 The instructional Design (Ethnomathematics Demonstration Lessons)

The study considered series of demonstration lessons after the field exploration of Akan ethnomathematics. After the field exploration through unstructured observation (see Appendix D) and Focus Group Discussion Guide (in Appendix K), the researcher considered applying the ethnomathematics concepts and considered its integration to the practical field to investigate its effect on students‟ academic achievement in mathematics as well as their interest and motivation in learning school mathematics. This demonstration lesson considered students intuition on formal mathematical standard (School mathematics) parallel with informal mathematics (Akan ethnomathematics). There were seven (7) ethnomathematics demonstration lesson (Appendix N). These demonstration lessons were termed as *ethno-demonstration lessons*. They were structured on the bases of seven themes (standards) of the SHS school mathematics curriculum (MOE, 2010). These included:

1. Numbers and Numeration.
2. Plane Geometry
3. Mensuration
4. Algebra
5. Statistics and Probability
6. Trigonometry
7. Vectors and Transformation in a Plane
8. Problem solving

The study considered selected lessons

Table 3.4: The Instructional Scheme of Work

S/n	Topic from the formal (school) curriculum	Curriculum structure for school level	Ethnomathematical moves	Mathematical Concept formation
1	Numbers and Numeration.	SHS 1 &2	Finger counting Oral numeration Debt tallying Counting-based games	Number and counting system from the informal perspective, grouping, ordering, sorting etc
2	Plane Geometry	SHS 1, 2 & 3	Measurement through foot and finger length, fathoms Geometrical shapes from the environment -Geometrical games, fathom gestures, adinkra symbols	Measurement of Length and Distance, Plane shapes, Angles,
3	Mensuration	SHS 1, 2 & 3	Area and perimeter of home-based artefacts Volumes of pots Construction of indigenous circular technology Earth-ware bowls	Perimeters, Areas and volume
4	Statistics and Probability	SHS 1 & 2	Games, eg. Ahyehyeaba, pilolo Counting systems Grouping and sorting things Arranging items in ascending or descending order Tracing and drawing emblems Tallying for debts	The concept of events and sample space probability measure Axioms of probability Compliment of event Addictive laws of probability Multiplicative laws of probability

Table 3.4 shows the instructional design scheme of work based on the regular teachers" action plan (scheme of work) for the term.

Selected mathematical concepts from these topics were considered with their suggested problem-solving strategies and application (mathematical processes). There were selected concepts from these mathematical standards from the curriculum. Lesson notes were prepared for the selected school mathematics and merged the formal mathematical system with informal ethnomathematics systems (Appendix N).

A suggestion of ethnomathematics framework module developed by (Forbe, 2020) was very useful.

The instructional design flowchart is illustrated below.

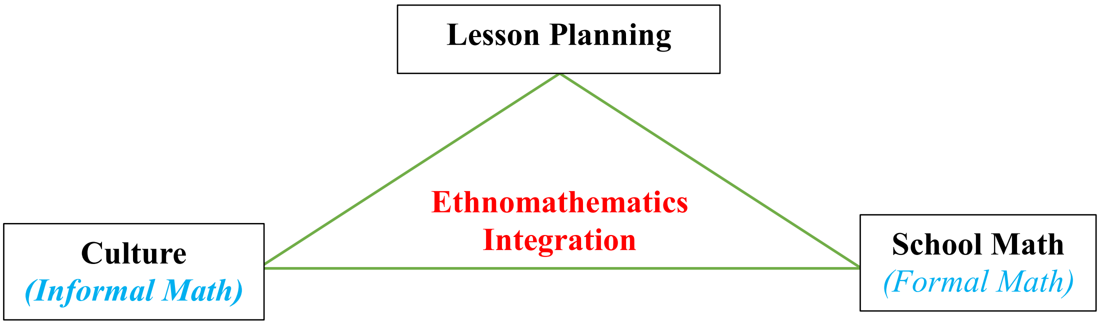


Fig 3.3: The instructional design flowchart

Ethnomathematics integration to teaching formal school mathematics (Ethnographic Approach) was considered in the formal lesson planning. This lesson planning considered several activities that reconciled the cultural mathematics (informal mathematics) with the school mathematics (formal mathematics) A term teaching with ethnomathematics integration was demonstrated. Topics were taking from their school mathematics syllabus (curriculum). and scheme of work of the class teachers. The study tested the effectiveness of ethnomathematics integration to teaching formal school mathematics using quasi experiment. Lesson was plan to integrate informal math (culture) with School Math (formal) curriculum. There was a followed-up with an experimental lessons to operationalize the existing theories on ethnomathematics (Forbes, 2018).

An application was sought from the school headmaster, through mathematics head of department before the commencement of the lesson delivery under the supervision of the mathematics HOD and occasional visit of supervisors. Lesson notes were written for each demonstration lessons (as seen from Appendix N). Each mathematical concept was taught three consecutive time within a week for the suggested five (5) periods. Students were taught series of these demonstration lessons for a period of one term after which assessment was done in a post-test form (see

Appendix F). Students obtained academic achievement scores have been tabulated in *Appendix M*

3.11 Data Analyses

Data collected was examined by first cross checking, coding, editing and tabulating. Since the study used the exploratory mixed design, both qualitative and quantity data were considered. Cross checking was done to ensure all the questions on each questionnaire were well answered through inter personal contact. In order to ensure internal consistency, the researcher guided the students and other focus group members to answer the questions well; by reading through with them where misunderstanding was clarified. For the sake of the students" scripts, all marking was done under conference marking with the HOD which was cross-examined for consistency. Coding was carried out to have the data in the "Statistical Package for Social Science (SPSS)" for data analysis. Before the analyses was done, the data collected were edited for consistency. It was then coded in Microsoft excel version 16 and then exported to SPSS version 21, Stata 7 and Minitab version 14. Coding was however done for specified qualitative and quantitative variables into the SPSS variable view.

Editing was performed to discover and remove errors in the collected data and the coded data. Tabulation was done to process information in a summarized form based on outlined themes that best fit ethnomathematics specified for the study. Data was analysed with the research objectives in mind. For the purpose of this research, data collection entry and organization were analysed with the help of SPSS, Stata, Minitab and Microsoft Excel, using descriptive statistics (i.e. frequencies, means, percentages, graph and cumulative percentages) and inferential statistics under the assumptions of the significant test for comparative means using the Standard normal t-test statistics and chi-square test of independence. The chi-square test of independence and associations was computed along the magnitude of qualitative methods for decision to be made based on the study‟s investigation of the effect of ethnomathematics approach in the teaching and learning process.

The research results were presented in the form of frequency distribution table which was later used to plot some graphs. Display of charts and graphs showing the frequencies of responses to the research questions was analysed to compare the means of the two paired treatment (control and experimental) groups from the ethnomathematics demonstration lessons. This played a contributing factor in description of the observed results using simple percentages (%), graphs and qualitative data analyses using the non-parametric chi-square test of independence as discussed in chapter four (4) hereafter. Since the study sought to find the impact of ethnomathematical moves of teaching and learning on students‟ academic performance, the comparative mean difference model (using the z-test and the t-test) with corresponding Analyses of variance (ANOVA) and non-parametric chi-square test of independence were very useful for the analyses.

Since the study also used qualitative analyses for to investigate participants responses to interviews and other questionnaires on the bases of their knowledge on ethnomathematics and cultural themes that support the teaching and learning of mathematics. The study employed the qualitative type of analysis for most especially for wrong or right responses that were justified by the participants‟ reasons for their choice of response or approach in solving the given questions. The percentage of students getting an item right or wrong was noted. In addition, the responses of students to constructed response items were grouped into themes and proportion of students whose response fell in a theme were noted. The researcher also tried to find out if there was a match between some participants" responses from the interviews and the test items and reconciled them with their knowledge in ethnomathematics. This was to assist in getting an in-depth understanding into what the participants were trying to put across.

3.12 Summary

The chapter looked at methodology adopted for this study. The study adopted the Exploratory mixed research methods. Under this method, both qualitative and quantitative methods were looked and described vividly it application to this study. The study also considered other types of research designs which was deemed supportive to the ethnomathematics study. These included descriptive and ethnographic research designs. These was taken because of the naturalistic nature of the research which seeks to explore the rich impact of socio-cultural activities on the teaching and learning of Mathematics.

The population considered was all general arts Senior High Students under the Gold Track of GES Double Tract education systems. These schools were purposively sampled under non-probabilistic convenience sampling techniques. Five Schools were selected from five regions of Ghana. These include Northern, Bono, Bono-East, Ahafo and Ashanti Regions of Ghana respectively. The researcher selected these schools from the respective regions because of proximity, closeness to the central point of Ghana, Techiman municipal in which the researcher resides. It made the demonstrations lessons more convenient and easy to access participants. These communities are also rich with many Ghanaian rich culture which best describe ethnomathematics pedagogies best described by (Forbes, 2018). In all 86 students were involved in the study and considered as the full participants for this research.

The study adopted at least four data collection methods: unstructured observations, focus group discussions, interviews guide, questionnaires and test scores of students. All instruments were carefully selected to constitute to more credible, dependent, transferable, natural valid and reliable. The study adopted various qualitative and quantitative data analyses which best fit the study"s intended objectives and research questions guiding this research.

CHAPTER FOUR

DATA ANALYSES AND PRESENTATION OF RESULTS

4.0 Overview

Data analyses and presentations is a paramount chapter of every scientific research. In this regard, the results of the data analysis as well as a discussion of the major findings are presented in this chapter. The significant and unique findings identified are interpreted and discussed within the existing literature on ethnomathematics paradigm. Data were collected and then analyzed in response to the problems posed in chapter 1 of this thesis.

The analyses and interpretations are based on the study"s research objectives and questions stated in chapter one. The analyses are guided by the following research questions:

1. What basic ethnomathematical activities are there in Akan communities that can support the teaching and learning of school mathematical concepts.
2. How does Akan Ethnomathematics (informal) connect School-based curriculum mathematics (formal) teaching and learning?
3. Is there any effect of ethnomathematics integration to teaching formal school mathematics on students" achievement in studying mathematical concepts?
4. What are teachers" and students" perceptions of the effectiveness and usefulness of ethnomathematics integration in teaching and learning of school mathematics?
5. What is the effect of ethnomathematics integration to teaching mathematics on students" interest and motivation in studying selected topics in Ghanaian core mathematics curriculum?

6. What problems are associated with the ethnomathematics integration in the teaching and learning of school mathematics.

The study considered an inferential statistic for the following alternative hypothesis for research question three and five respectively:

H_{03}: There is no significant effect of ethnomathematics integration to teaching formal school mathematics on students" achievement in studying sschool mathematical concepts.

H_{05}: Students" interest and motivation in studying school mathematics curriculum is independent of ethnomathematics integration to teaching mathematics.

4.1 Demographic Characteristics

The study respondents comprised the mathematics teachers and students. Their views were sought on their knowledge of ethnomathematics applications to formal and informal teaching and learning. The data was analyzed from responses to questionnaire from sampled teachers and students.

4.1.1 Demographic Distribution of Teachers

Results of teachers" demographic distribution are based on response from teachers" questionnaire from Appendix G. In all, a total of 112 teachers were sampled and responses on the various variables analysed to constitute a cumulative 100%.

Table 4.1 presents results of demographic information for the study respondent teachers based on qualification. Mathematics teachers" qualification guiding their posting and line of teaching duties within the selected schools were coded on whether they have Higher National Diploma (HND), Bachelor Degree, Master degree or any other certificates.

Table 4.1: Teacher Qualification

Teacher Qualifications			
		Frequency	Percentage (%)
Valid response	HND	7	6.3
	Bachelor Degree	88	78.6
	Master Degree	12	10.7
	Any Other	5	4.5
	Total	112	100.0

Source: field survey 2020

Table 4.1 presents information on qualification of mathematics teachers in the chosen schools. The modal qualification of these teachers was those who had bachelor degree constituting 88 (78.6%) of the total respondents. Twelve (12) teachers (10.7%) hold master degree. Few, comprising 7 (6.3%) were with HND (of which almost all of them were on their national service or attachment). The rest 5 (4.5%) held other form of qualification such as technical certificates or perhaps Doctoral degrees.

Table 4.2 shows teacher professional ranks from the sampled schools. The ranks ranges from senior superintendent, principal superintendent, assistant director I and II, Deputy director to director.

Table 4.2: Teacher Professional Ranks

Teacher Professional Rank			
	Rank	***Frequency***	***Percentage (%)***
Valid response	Senior Superintendent	12	10.7
	Principal Superintendent	62	55.36
	Assistant Director (1&2)	34	30.4
	Deputy Director	3	2.7
	Director	1	0.9
	TOTALS	112	100.0

Source: field survey 2020

From Table 4.2, teacher professional ranks ranges from senior superintendent to Director Level. Majority of the teachers are Principal superintendent and Assistant director I and II constituting 62 (55.36%) and 34 (30.4%) respectively. Twelve teachers (10.7%) were senior superintendent who moved from the Basic school to the Secondary level after further studies and were waiting for their upgrade. Only three (2.7%) teacher has reached deputy director level with one (0.9%) being a director.

The study considered their ethnicity and gender distributions as illustrated from the pie-charts in Figure 4.1.

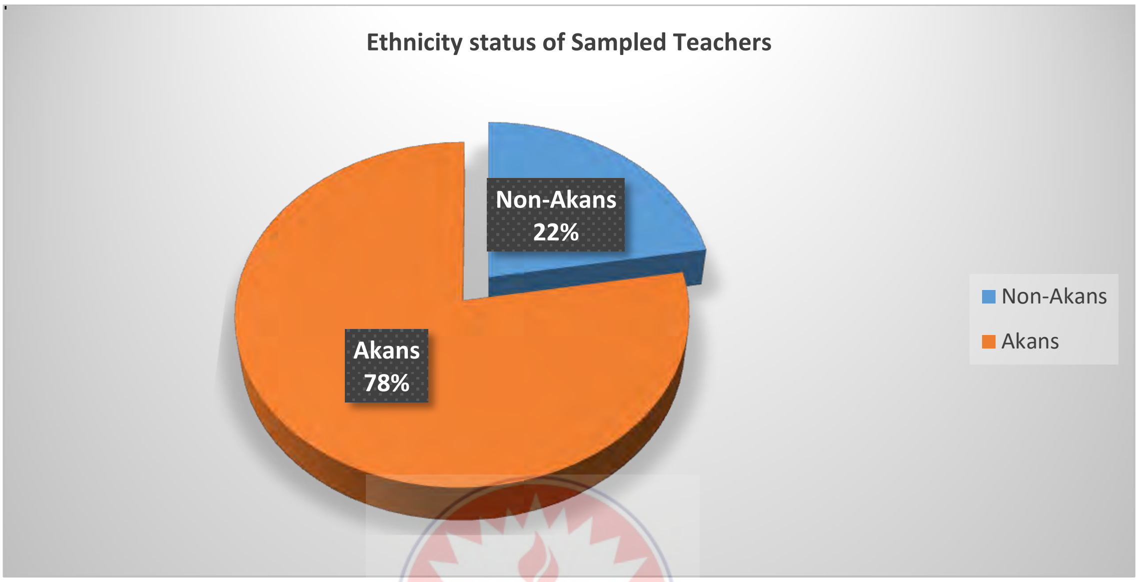


Figure 4.1a: Distribution of teachers based on Akans and Non-Akans

The distribution of teachers based on whether they are Akan or non-Akans has been presented in Figure 4.1a. The distribution of the sampled teachers with respect to ethnicity background (Akans and non-Akans) were collected through questionnaires. Relatively, about 78 % of the sample size of the teachers are Akans and hence come from the Akan communities whiles the rest of the 22% are non-Akan teachers. It is noticed and confirmed by ethnomathematics to be good if mathematics teachers who come from the learner‟ own environment or community teaches them (Antoniadou & Dooly, 2013; Sunzuma & Maharaj, 2019; Teye, Tetteh, et al., 2018) . This normally ensure an easy means by which ethnomathematics become more applicable. Eighty-eight percent (88%) of the teachers are males whiles the rest 12% are female mathematics teachers.

Posting of teachers are done by considering teachers who reside within the community and who understand the language, cultural and customs of the learners stand the chance to impact ethnomathematics well than teachers who don"t understand the culture of the learners (Herawaty et al., 2019).

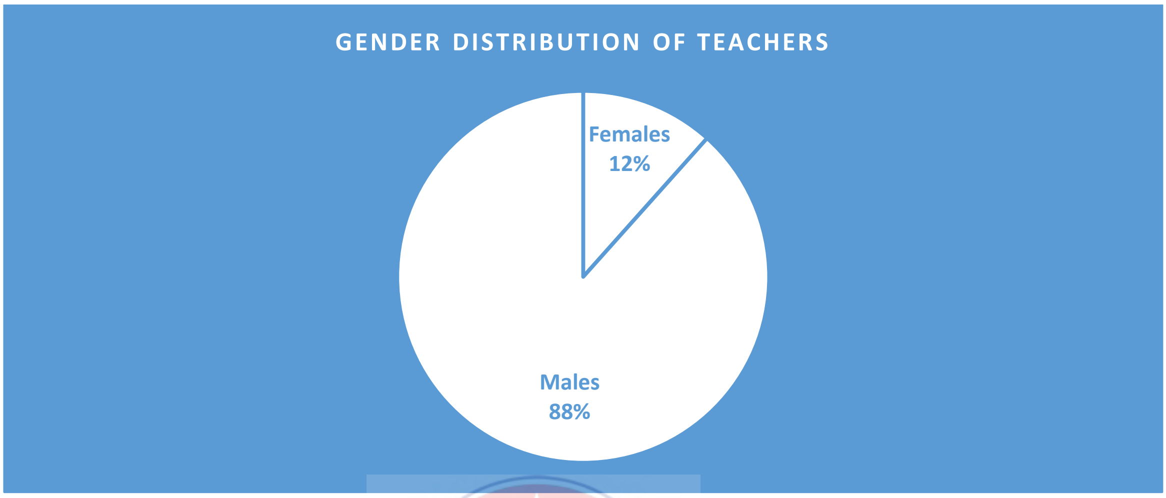


Figure 4.1b: Distribution Teachers based on Gender

Figure 4.1b gives gender distribution of teachers specified in proportionate percentages by each sector of the pie-chart. Male mathematics teachers were 99 constituting 88% while female mathematics teachers were 13 constituting 12%.

Figure 4.1b shows the levels respondent teachers teach in the selected schools.

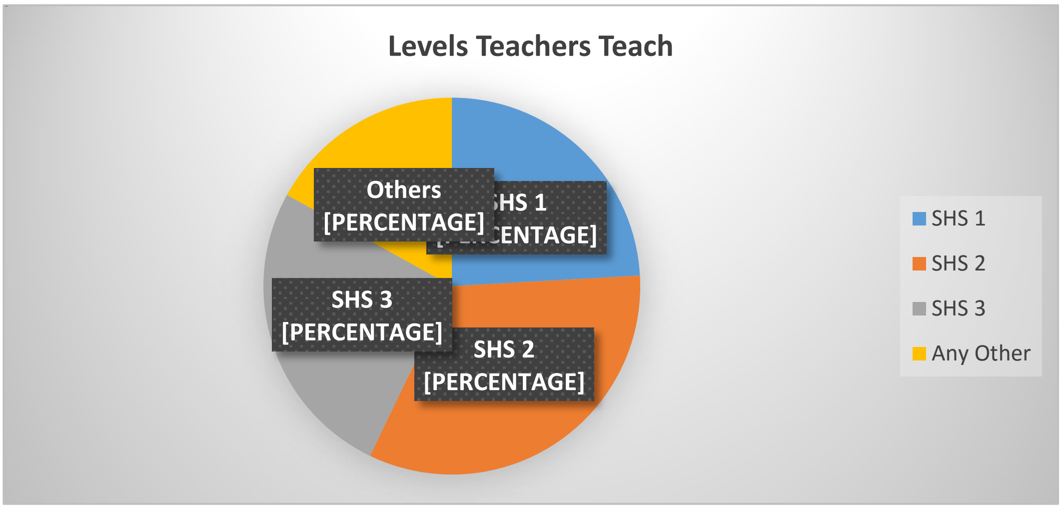


Figure 4.2: Levels respondent mathematics teachers teach

From Figure 4.2, out of the 112 teachers sampled from the selected schools, 24% of the teachers teach in SHS 1 class, 33% of them teach in SHS 2 class, 26% teach in the SHS 3 class whiles 17% are mathematics teachers who occupy various positions in the school other than teaching.

Similarly, Figure 4.3 further shows teachers decision as to whether they encourage or discourage ethnomathematics integration in the curriculum implementation process.

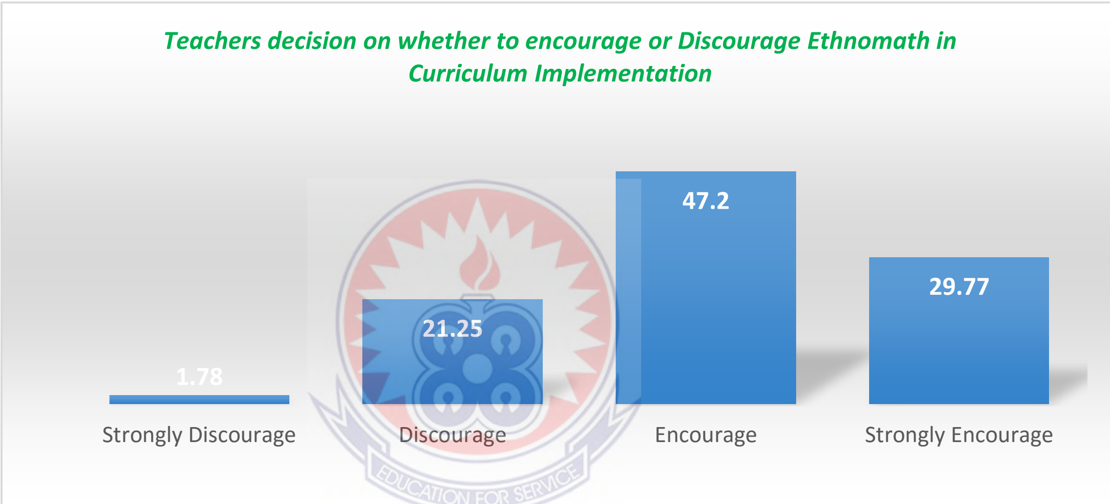


Figure 4.3: Teachers decisionon on whether to encourage or discourage ethnomath integration in curriculum implementation

Figure 4.3 shows teachers‟ decision on whether they encourage or discourage ethnomathematics integration in teaching. Figure 4.3 shows teachers endorsement to ethnomath integration in teaching mathematics; whether they encourage or discourage ethnomathematics integration into formal teaching of school mathematics. The study inquired from mathematics teachers‟ whether they endorse the use of ethnomathematics integration to teaching school mathematics. Sampled teachers teach in all the Senior High School (SHS) levels from SHS1, SHS2 and SHS3 as well as those found in other sectors of the education such as administrators of the schools who have taught the mathematics for several years before.

Teachers share their experiences as to whether they are aware of ethnomathematics approach of teaching mathematics and its application in mathematics education in Ghana. Majority were unsure of it though, but when it was explained to them, they were probed on whether to encourage its implementation or discourage it from curriculum implementation process. From Figure 4.3, modal bars suggest their endorsement to encourage it by relatively 76.97% as against those not interested in the suggestive implementation process of about 23.03%.

The study inquired about their awareness of ethnomathematics in the curriculum implementation process. Figure 4.4 shows the ratio of their awareness to unawareness.

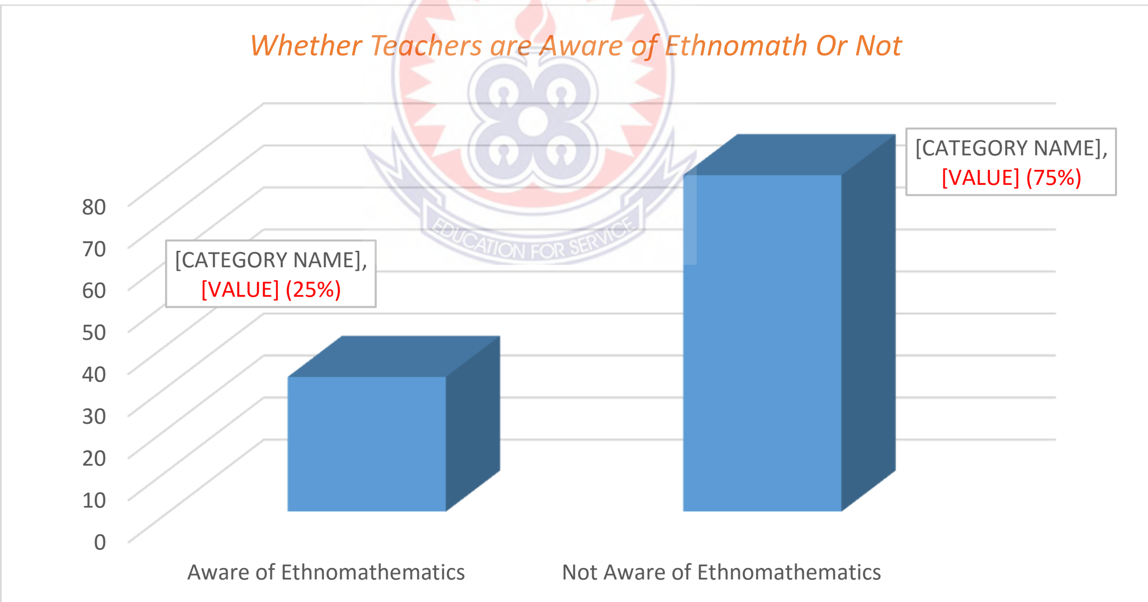


Figure 4.4: Bar graph showing Teachers awareness of Ethnomathematics approach in teaching

From Figure 4.4, the ratio of teachers‟ awareness and unawareness of the ethnomathematics approach in teaching mathematics is 32:80 (24%:75%), that is 1:4 in its simplest ratio. Out of every four teachers, only one is aware of ethnomathematics application in the pedagogical development in the curriculum implementation process. In order to cope with ethnomathematics approach in teaching mathematics, stakeholders of mathematics education need to create awareness of this in the school ranks and files (Colwell & Enderson, 2016). This is the main campaign ethnomathematics philosophers seeks to create awareness so as to rebrand the teaching pedagogies in the field of mathematics education (Bishop, 1998; D‟Ambrosio, 1989; Davis, 2016; Orey, 2017; Pradhan, 2017; Rosa & Orey, 2011; Shirley, 1998). If it so exists, there should be education for all Ghanaian mathematics teachers. Ethnomathematics should also be part of the teacher education program so as to groom teachers from their training grounds. The new curriculum standard emphasises on the need for teachers to consider cultural identity and global citizenship of the learner (NaCCA, 2019).

4.1.2 Demographic Distribution of students

This section discusses the demographic information on sampled students. In all, there were 86 students sampled to constitute two classes (Arts A and Arts B) respectively. Data analyses was based on students‟ response to questionnaire as seen from Appendix E.

The multiple bar graph in Figure 4.5 shows students distribution of chosen classes with gender ratio.

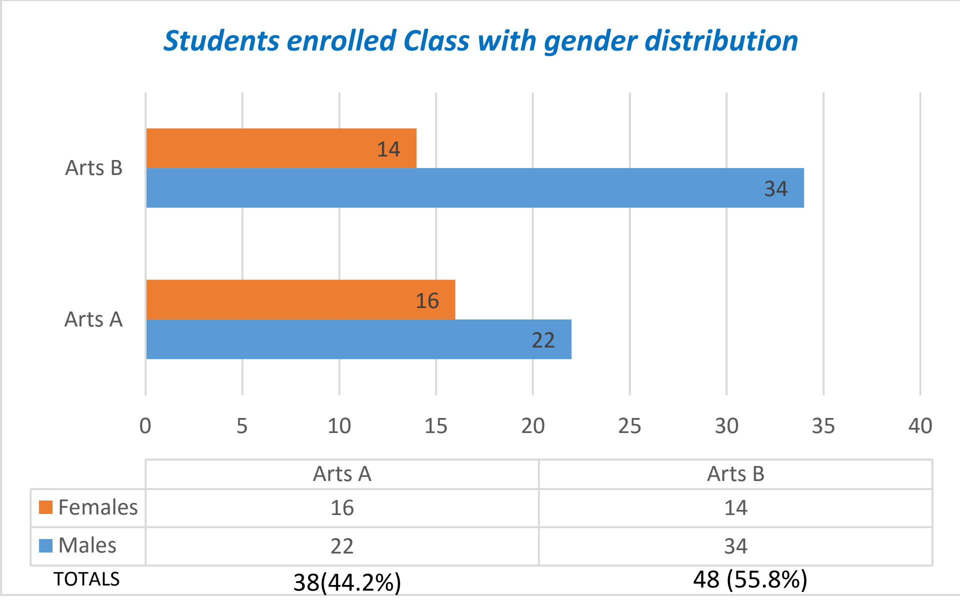


Figure 4.5: Gender distribution of Students by enrolled Class.

Figure 4.5 gives the distribution of Arts A and B classes considered and purposively chosen as study participants for the quasi-experiment for the ethnomathematics. Two of the General Arts classes A and B were considered. There were 38 students in Arts A class constituting 44.2%. There were 48 students in Arts B class constituting 55.8%. Fifty-six students constituting 65.9% were males whiles 30 constituting 34.1% proportion were females. In all, 86 students were considered for the quasi-experimental study with the ethnomathematics approach of teaching.

Figure 4.6 gives the distribution of students based on their tribal status as whether Akan or non-Akan. The respective classes in Arts A and B with Akan tribal status is highlighted in Figure 4.6.

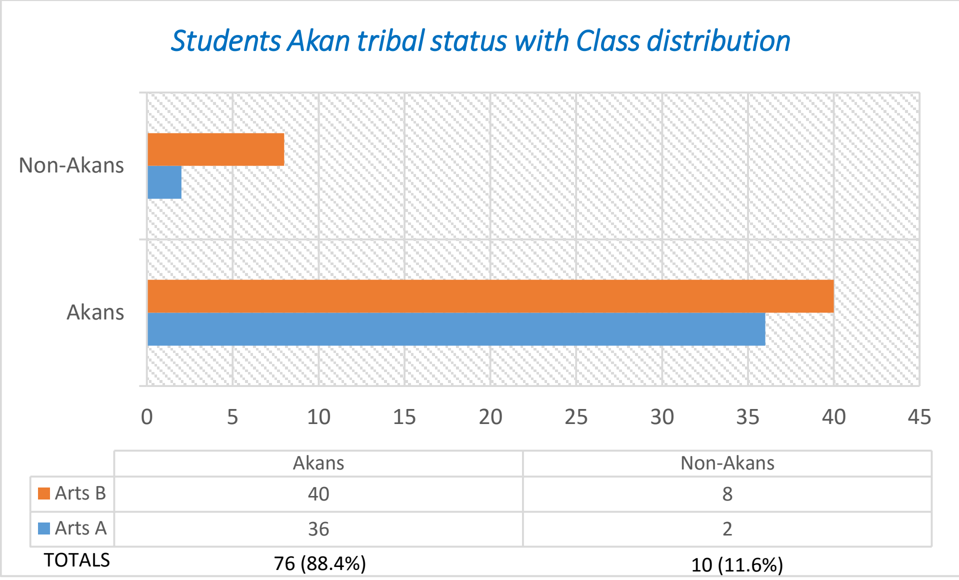


Figure 4.6: Students Akan tribal status with Class distribution

From Figure 4.6, the distribution of Arts A and B classes with their tribal ratio is given for the quasi-experiment on ethnomathematics lessons. In all, 76 (88.4%) out of the 86 students were Akans whiles the rest 10 constituting 11.6% were non-Akans. There were 38 students in Arts A constituting 44.2%. There were 48 students constituting 55.8% proportion.

4.2. Research Question 1:

What basic ethnomathematical activities are there in Akan communities that can support the teaching and learning of school mathematical concepts?

Akan ethnomathematics is seen in diverse ways in their socio-cultural context. The study explored in this section, some basic Akan ethnomathematics activities that are deemed to support the teaching of some of the mathematical concepts in the formal standards of the curriculum. The data gathered was through observations and interviews as seen from Appendix D. The section further investigated participant opinion on their knowledge of mathematical applications to the products and processes of their mathematical thinking. The study also demonstrated in addition, the mathematics implication of these ethnomathematics to the curriculum implementation process in teaching through Realistic Mathematics Education (RME) model. The syllabus strands and sub-strands suggest the teaching of number, algebra, geometry and data concepts by considering "cultural identity and global citizenship" (MOE, 2020). The study explored the implication of Akan ethnomathematics activities supporting the teaching and learning of selected mathematical concepts in the school curriculum by considering such suggestions for teaching school mathematics.

4.2.1 Selected Basic Akan ethnomathematics activities

There a several Akan ethnomathematics which can be introduced to students as class activities to support the formal implementation of the curriculum in the formal or classroom mathematics. Table 4.3 below shows some of the selected Akan basic ethnomathematics such as construction of Adinkra symbol (*Mmere dane, Gye Nyame, Adinkrahene*), stroking and tallying concept for data collection, measurement of time (*mmere*), counting and geometrical games. Others include finger counting techniques for operations, naming techniques, hand stretching, farm practices (ridging and mounding), folktales and storytelling, riddles and puzzles (recreational ethnomathematics).

Sampled teachers were interviewed on their recognition of interconnection between some selected Akan basic ethnomathematics (informal) with school mathematical concept (formal) teaching. Their recognition is supported by whether they use them to teach or not. Results of teachers" identification of selected Akan ethnomathematics activities with its implication to school mathematical concept is presented in Table 4.3.

Table 4.3: Teacher' identification to Whether Akan Basic Ethnomath has implication to their understanding of selected school mathematics.

	Basic Ethnomathematical Activities	School mathematical concept	Used Often (%)	Used occasionally (%)	Do Not Use at all (%)
1	Adinkra symbol (*Mmere Dane, Gyenyame, Adinkrahene*)	Shape and space	13 (11.6%)	96 (85.7%)	3 (2.7%)
2	Stroking and tallying	Statistics, data collection and number counting	44 (39.3%)	67 (59.8%)	1 (0.9%)
3	Measurement of time (*mmere*)	Time, shape, space	54 (48.2%)	58 (51.8%)	0 (0%)
4	Counting and geometrical game	Number counting, numeration system, geometry	42 (37.5%)	70 (62.5%)	0 (0%)
5	Finger counting	Number counting, numeration system	67 (59.8%)	45 (40.2%)	0 (0%)
6	Naming techniques	Number counting, numeration system, sequence	55 (49.1%)	56 (50%)	1 (0.9%)
7	Hand stretching	Measurement of lines and distances, geometry	43 (38.4%)	69 (61.6%)	0 (0%)
8	Farm practices (ridging and mounding)	Measurement of area, perimeter	62 (55.4%)	50 (44.6%)	0 (0%)
9	Folktales and story telling	logical reasoning, Problem solving strategies	86 (76.8%)	26 (23.2%)	0 (0%)
10	Riddles and puzzles (recreational ethnomath)	Algebra, logical reasoning, sets	53 (47.3%)	54 (48.2%)	5 (4.5%)
	Total number of students				86 (100%)

Table 4.3 gives teachers" identification of some basic Akan ethnomathematics (from informal) in connection to the teaching of some school mathematical concept (from formal). They responded to whether they often, occasionally or do not use it to help build students understanding of school mathematics in the formal classroom teaching. The number of teachers" responses are expressed in respective percentages in Table 4.3.

The selected Akan basic ethnomathematics and their recognition to some Akan Adinkra symbols such as *Mmere dane, Gye Nyame, Adinkrahene* were recognised by 96 representing 85.7% of the teachers that they occasionally establish the interconnection as against 13 (11.6%) who used it often and 3 (2.7%) who do not establish the interconnection at all.

In the „stroking and tallying concept for data collection in recognition to statistical concept from the formal curriculum strand, teachers" *valid* response to whether they often, occasionally or do not establish interconnection were 44 (39.3%), 67 (59.8%) and one (0.9%) respectively. On their recognition of „measurement of time" (*mmere*) to create linkage of time, space and shape. Teachers" *valid* response to whether they often, occasionally or do not establish interconnection were 54 (48.2%), 58 (51.8%) and 0 (0%) respectively. Counting and geometrical games to associate number counting, numeration system and some geometry forms also recorded teachers" *valid* response to whether they often, occasionally or do not establish interconnection as 67 (59.8%), 45 (40.2%) and 0 (0%) respectively. Again, Akan ethnomathematics explored on „naming techniques" to link formal Number counting, numeration system and concept of sequence recorded teachers" *valid* response to whether they often, occasionally or do not establish interconnection were 55 (49.1%), 56 (50%) and one (0.9%) respectively „Hand stretching" activity to link formal concept of Measurement of lines, distances and geometry rated 43 (38.4%), 69 (61.6%) and zero (0%) respectively. Teachers" *valid* response to whether they often, occasionally or do not establish interconnection to exploration of farm practices in the form of ridging and mounding of mounds done by most Akan people to check on their measurement of acres and hectares farmed. The conception of these is linked to the formal school Measurement of area and perimeter estimation. teachers" response. 62 (55.4%), 50 (44.6%) and zero (0%) respectively. On the activities using folktales to create linkage to student logical thinking and problem-solving strategies, there was 86 (76.8%), 26 (23.2%) and zero (0%) respective response on establishing the interconnections. Teachers were drilled with Akan ethnomathematics activities on riddles and puzzles as recreational ethnomathematics to associate their Algebra concept, logical reasoning skills and sets (collection of things from their compound). teachers" *valid* response to whether they often, occasionally or do not establish interconnection were 53 (47.3%), 54 (48.2%) and five (4.5%) respectively.

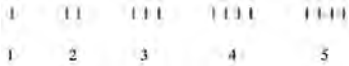
In conclusion, majority of the teachers could recognise that, they occasionally exposed students to some Basic Akan ethnomathematics to help them understand corresponding formal school mathematics more easily. To clearly associate the ethnomathematics support to the teaching of the formal curriculum, there is the need to mathematicise these activities as suggested by Peni (2019). These can be done through activity-based teaching and learning to merge the informal and formal mathematics systems to support student understanding.

Some of the Akan cultural pieces (folktales, textile designs, rhymes, games, artefacts, naming techniques, arbitral measurements, proverbs, Adinkra symbols, riddles and puzzles) which have ethnomathematics implications have been presented in Table 4.4. The Table gives various Akan basic and most popular ethnomathematics activities that suggest informal mathematical applications and interconnectedness with the teaching and learning of school mathematics.

Some of these basic ethnomathematics existed in the form of folktales crafted to deduce logical reasoning about life. Akans tell *ananse stories* to characterize behaviour deficiencies about natural logic and entertain the people. Ananse (the trickster), stands for any person whom the story is told about. Folktales, fables, trickster stories are told by the elderly to educate the young based on life experiences. These provide rich context, developing knowledge and skills in speech, reading, numeracy and general science education. *Ananse and the yam mounds' story* for example is used to demonstrate or introduce a mathematical investigation into even and odd numbers (Mereku & Mereku, 2013). Words problem solving strategies could be crafted using folktales.

The study explored in addition some basic Akan Ethnomathematics in Table 4.4 below. Majority of the Akan ethnomathematics centers on folktales, textile designs, rhymes, games, artefacts, naming techniques, arbitral measurements, proverbs, Adinkra symbols, riddles and puzzles.

Table 4.4: Some Basic and popular Akan Ethnomathematics

Basic Akan Ethnomathematics	Exemplifications	
1. African textile designs		Adinkra symbols, Kente, Clothes (Ntoma), Gye-Nyame,
2. Stroking and tallying		Debt tallying, payment, data records, arbitrary counting
3. Measurements		Namontenten, Kwansin, basafa, Bere, sima, dɔnhwere, olonka,
4. Games		Counting games (Ludo, Oware) logical games (Dame), Geometric games (Peele)
5. Finger Counting		Informal numeration, counting, basic sum operations
6. Name		Baako, Manu, Mansah, Anane, Anum, Nsia……Badu, Duko…
7. Adinkra symbols		Adinkrahene, Gye Nyame, Nyamedua, mmere dane, woforo dua pa a…
8. Artefacts		Earth-Bowl ware, architectural houses…
9. African folktales		Ananse and wisdom pot, Ananse and the yam mounds…
10. African rhymes		Rhyme game to consolidate counting and addition facts (baako, mienu, miensa ne nnan…)
11. Proverbs		Ti korɔ nkɔ agyina, Baanu so emmia, wonam mmienu sum fidie a…

Adinkra clothes made by the Akan of Ghana illustrate geometrical patterns that can be used to link formal concepts in the teaching and learning of geometry. Adinkra is printed by either block-print or screen-print technique. The motif or pattern is carved from wood and linked with proverb, traditional saying, historical event and illustrated story of some everyday expressions. The Figure 4.7 below shows some kente cloth made with adinkra design showing geometric ethnomathematics.

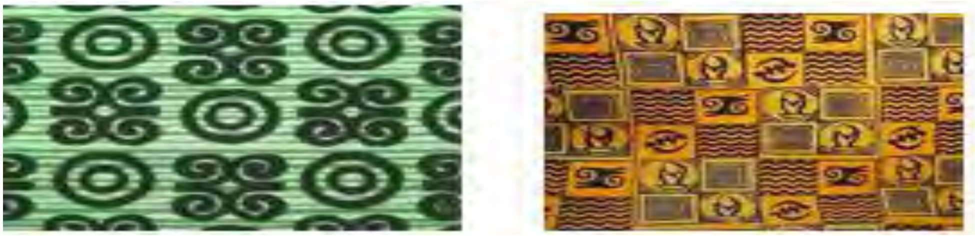


Figure 4.7: Some examples of Adinkra cloth (Afroetic.com, 2012)

Students observed various Akan adinkra symbols with samples from Figure 4.7. They were asked to construct adinkra motifs or patterns with maths drawing instruments and describe the geometrical shapes and properties. Some of the selected *adinkra* symbol explored are the "*adinkrahene (*chief of Adinkra)*, woforo dua pa a (*if you climb a tree*), Gye-Nyame* (Except God the Creator) *and mmere-dane* (time Changes)" adinkra symbol seen from Table 4.5.

Table 4.5: Construction of some selected Akan Adinkra symbols

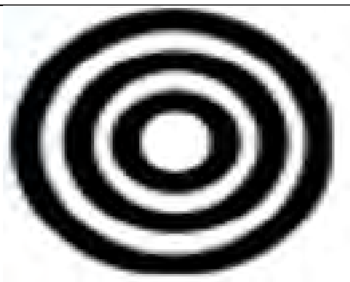
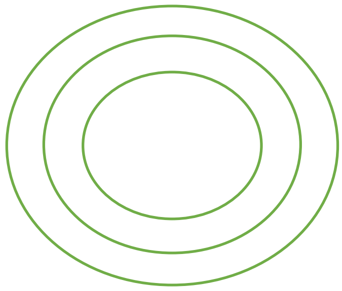
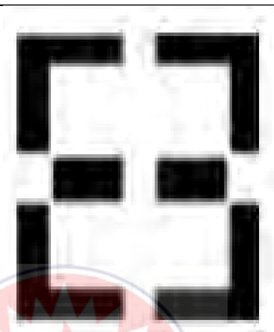
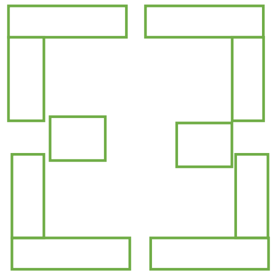
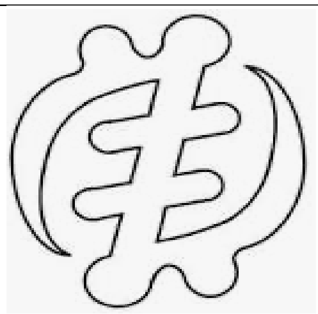
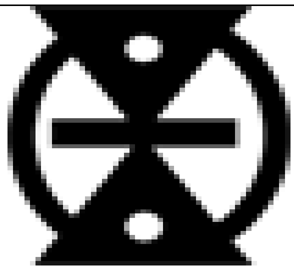
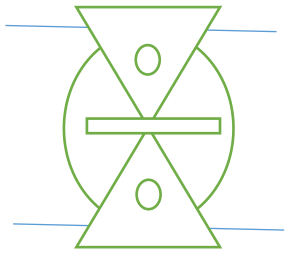
Adinkra name	Literal translation of Symbol	Adinkra symbols	Formal Construction
Adinkrahene	*"Chief of adinkra symbols"* (Greatness, charisma, leadership)		
woforo dua pa	*"When you climb a good tree"* (Support, cooperation)		
Gye-Nyame	*"Except for God"* (Supremacy of God the creator)		
Mmere-dane	*"Time changes"* Change, life's dynamics		

Table 4.5 gives a sample of what students observed and constructed from Adinkra symbols based on their virtualization, texture and perceived dimensions. The selected adinkra symbols constructed were *adinkrahene (chief of Adinkra, woforo dua pa a* (if you climb a tree), *Gye-Nyame (*Except God the Creator) and *mmere-dane* (time

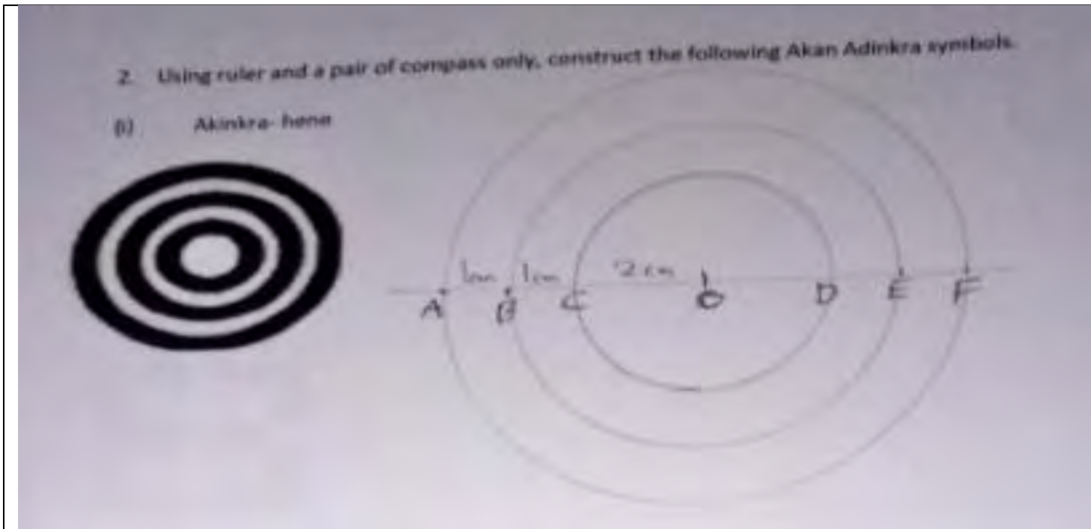
Changes) symbols respectively. The construction was done using a pair of compasses, ruler, protractor and some mathematical set tools just as it is usually done in the formal teaching of construction topic.

In conclusion, majority of the students constituting 95% performed well with a mean of 88% accuracy. The various activities done to support the interconnections are discussed in the subsequent sub-section boxes 1, 2 and 3.

***Activity**: Student construct the following Akan Adinkra symbols in their formal construction lesson.*

1. "*Adinkrahene* (Chief of Adinkra)
2. *Woforo dua pa a* (if you climb a tree)
3. *Gye-Nyame* (Except God the Creator)
4. *Mmere-dane* (Time Changes)

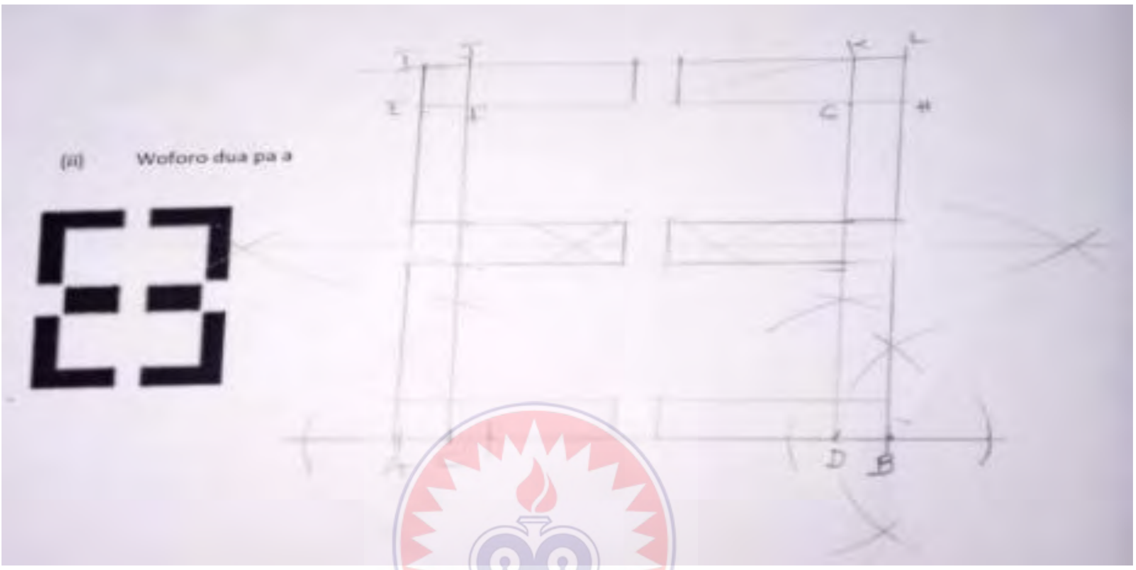
Students are guided to construct some selected Akan *adinkra* symbol including adinkrahene, woforo dua pa a, *Gye-Nyame* and *Mmere-dane* symbols respectively as seen from Boxes 1, 2 and 3.



Box 1: Construction of Adinkrahene Adinkra symbol

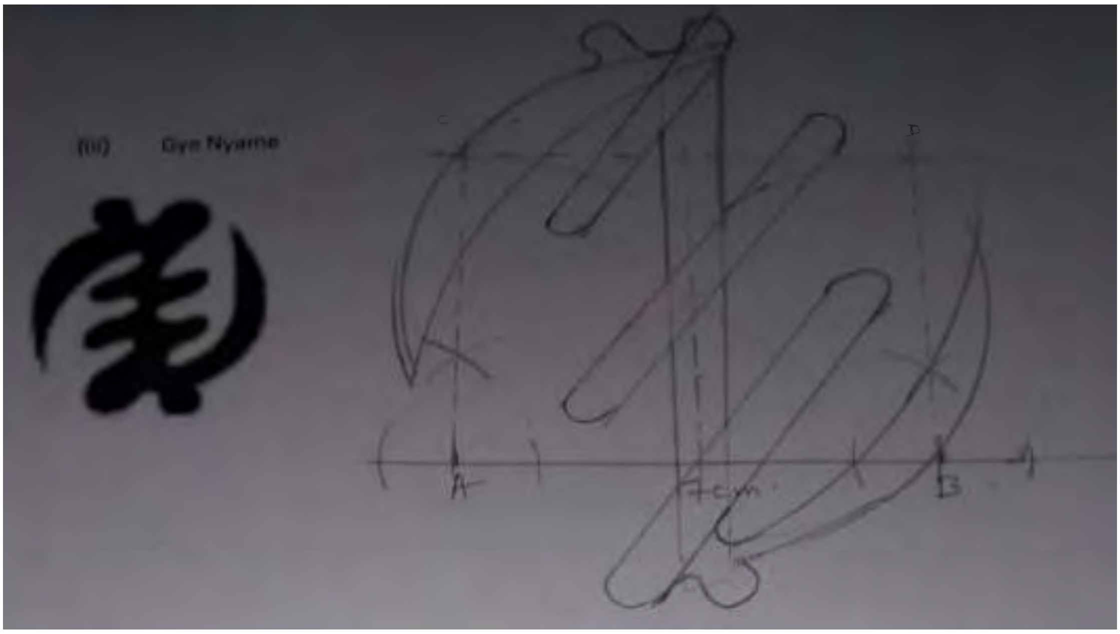
Students' construction of adinkrahene symbol is given in box 1. They were able to identify the orbital circles and labelled the base respective segments A, B, C, D, E and F with centre O as the origin. A radi ratio of 2:1:1 centimetre of each circle was constructed consecutively to form the adinkrahene symbol.

The Box 2 shows students' construction of "woforo dua pa a" adinkra symbol.



Box 2: Construction of 'woforo dua pa a' Adinkra symbol

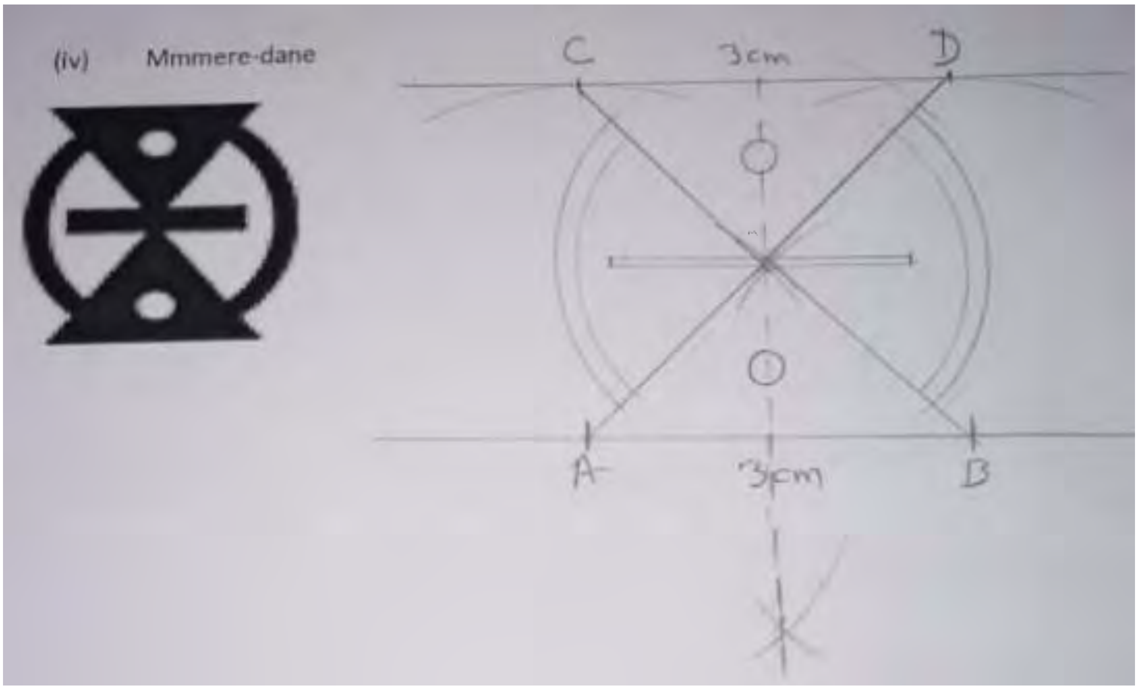
Students set a base line AB of 7cm and constructed a perpendicular bisection to each point to produce two perpendicular lines /AJ/ and /BL/. A bisection of these lines produced the middle base-lines. Students traced on the first baseline 1cm to locate the points ACDB to link the points WFGH and IJKL respectively to produce a trace of the *'woforo dua pa a'* adinkra symbol. A similar approach is given in Box 3 for the construction of '*Gye-Nyame'* adinkra symbol.



Box 3: Construction of Gye-Nyame Adinkra symbol

Box 3 gives the construction of the *Gye-Nyame* symbol. The symbol is popular in Akan. It is link to religious transcription of the Supremacy of God the Creator. Since the symbol has irregular shape, students struggled in its formal construction. Tracing was used in some cases to support the formal construction process.

A base line //AB//=7cm was set to produce two parallel lines //CD//. Students bisected line //AB// and constructed three diagonals across the bisected line to //AB//. Two opposite arcs were constructed from the opposite diagonals from point B and C respectively to finalise the arbitral shape of the *Gye-Nyame* adinkra symbol. Below is the formal construction of *Mmere-dane* Adinkra symbols seen in Box 4.



Box 4: Construction of Mmere-dane Adinkra symbol

Box 4 showcase students construction attempt for the *mmere-dane* (time changes) adinkra symbol. Students observed properties of *the Mmere Dane* adinkra symbol constructed and identified them as rectangles, circles, triangles, two lines of symmetry and rotational symmetry of order two. To construct this symbol, students drew the base line //AB//=3cm and produced a parallel line //CD//. Diagonal lines were constructed to link the line segments //AD// and //BC// respectively to meet at point M. At point M and with radius 2cm, two opposites arcs are constructed to link the two respective opposite diagonals to complete the symbol structure. Two small circles of about 0.5cm were inscribed into the two opposite triangles AMB and CMD respectively to complete the construction process of the *mmere-dane* adinkra symbol.

Students enjoyed the construction processes and had the extrinsic empathy to explore more adinkra symbol construction. When student own and feel the mathematics from their door steps, they attempt to follow and understand the mathematics content better (Davis, 2013). Similarly, other *adinkra* symbols were formally constructed using mathematical set.

4.2.2 Stroking and Tally Counts

The tallying is used traditionally to signify records of the occurrences of events with time bounds. Example, the time of owing somebody and probably mode of payment methods. This has ethnomathematics concepts believed to conform to number counting system, statistical tools for collection and organizing data (Figure 4.8) and the probability of occurrences of events such as to *borrow (bosea)* or to *pay (akatua).*

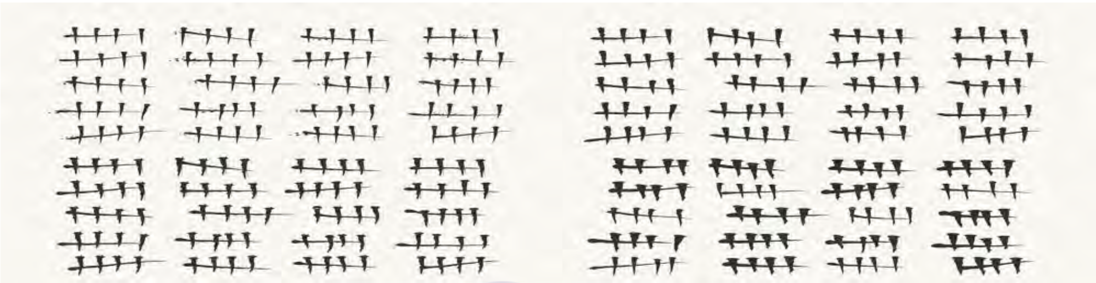


Figure 4.8: Tally system of counting adapted from traditional ethnomathematics

The tallying system in Figure 4.8 could be modified to assist students in diverse mathematical concepts that relate statistical data collection and number counting systems. This ethnomathematics is currently used by most teachers when teaching statistics in preparing frequency distribution table as seen from Table 4.6. The Tally counting from Figure 4.8 is not only limited to notches on sticks, tallies are most likely the oldest means of recording quantities in human history (Hardegree, 2003; Weibull, 2013). It is also the one that has stuck with us the longest means by which people express their knowledge in mathematics. The Akans in the olden days used this for accounting systems by the wealthy folks who give loans called *sandanho* meaning *(mark it on the wall)* as an evidence loan repayment and express means of payments used in the 18th century. It was sometimes used to mark days in which event occurs.

A tally stick is simply a piece of wood in which notches have been made, representing some quantity. More advanced forms have different notches, e.g., deeper grooves or crossed notches, to represent larger quantities. For recording some transfer of goods, tallies where sometimes made and split in two along the tally so that later the transfer could be validated by both parties. When used for recording debts, tally sticks were often made shorter as parts of the debt were paid, removing notches corresponding to the returned amount. Not much more than a way to record transactions and quantities, tally sticks nonetheless have played an important role in many civilizations, as the need for such records have become apparent. Many are truly a beautiful piece of history, as their importance often warranted great care in their creation. Many illustration of number concepts arbitrary illustrated through cultural representations are there, testified to suggest ethnomathematics of the ancient people since time antiquity, (Hardegree, 2003; Interactive Stem, 2015; Swetz, 1989).

The historical, logical and didactical background to the tallies has long been considered as ancient. In the concept of number formation, (Bezuidenhout, Henning & Fitzpatrick, 2019) offer comments on the long and diverse history of the use of tallies as an artefact for counting numbers, from „early stone age" to more recent centuries. Presently this approach to numbers is among many cultures of which Akans are of no exception. Sequences of tallies can also be seen as a practical artefact of ancient times, but are still largely in use even today when counting a not-too-large population, often implemented by means of groupings by five:

1 2 3 4 5 6 . . .

Activity/experimental example: Student participants were guided to use the tallying concept to prepare a frequency distribution table for the occurrence of face of die thrown 48 times as seen from Table 4.14 below. Table 4.14 shows how students represented the information in frequency distribution table through stroke tallying experiment. Results are presented in Table 4.14 below

6	1	3	2	4	5	1	1	3	3	1	2
1	6	5	6	3	4	2	6	5	4	4	3
2	2	5	4	6	6	4	5	2	6	5	5
5	4	4	5	4	5	4	2	2	3	4	4

Table 4.6: Frequency distribution from using tallying.

Die Face (x)	*Stroke Tally*	*Frequency* (f)	fx	fx^2	*Cum frequency*
1	~~////~~	5	5	5	5
2	~~////~~ ///	8	16	32	13
3	~~////~~ /	6	18	54	19
4	~~////~~ ~~////~~ //	12	48	192	31
5	~~////~~ ~~////~~	10	50	250	41
6	~~////~~ //	7	42	252	48
TOTALS		**48**	**179**	**785**	

Students use the ethnomathematics tallying concept to statistical data analyses using frequency distribution table as seen from Table 4.6. From the frequency distribution in Table 4.6, students used the information to find the modal throw as 4 since it carries the highest frequency. Students were guided through various statistical concepts such as measurement of central tendencies (mean, median and mode). The variability measure of the distribution was also computed. The measurement of central tendencies and spread were computed as follows:

$$\bar{X} = \frac{\sum fx}{\sum f} = \frac{179}{48} = 3.73$$

Whilst the mode is face 4, the median face throw lies within the $\frac{1}{2}N^{th}$ position. i.e

Median$= \frac{1}{2}N^{th} = \frac{1}{2} \times 48 = 24^{th}\ position \approx 4$

Similarly, the variance was computed as

$$\sigma^2 = \frac{\sum fx^2}{\sum f} - \left(\frac{\sum fx}{\sum f}\right)^2 = \frac{\sum fx}{\sum f} - \bar{X}$$

$$= \frac{785}{48} - \left(\frac{179}{48}\right)^2 = 3.73$$

The Ludo game has probability and statistical concepts best illustrated by ethnomathematical concepts from informal position as well as formal mathematical concepts in statistics and probability and general number concepts. The teaching of mathematics using games support the teaching of mathematics. This finding is in consistency with Nabie (2015) study on confession of Primary School teachers confessing on the need to integrate mathematics teaching with traditional games ethnomathematics.

4.2.3 Akan measurement of Time (*Bere*)

Time consciousness is very important. The Akan recognizes time measurement called *bere* or *mmerɛ*. Time in hours is referred to as *donhwere, sima (minutes) and pɛre* or *anibɔtƐtƐ* (seconds). One hour is *donhwere baako*, *donkoro (*1 oclock PM), *nonmmiene (2* O‟clock pm*)*, *nonmminsa* (3 O‟clock pm), *nonnan*, etc. They watch the movement of the shadow to predict time and events. Observance of sundown getting shorter to any object under the sun (*Owia*) tells the concept of noon (12 o‟clock) as *aha*. This corresponds to the greetings given at that time as *maaha,* (good afternoon). When they watch the shadow is going to near the object, they think time is closure to 12 o'clock and when sun is just above the man (or the observed object), they also guess time is 12 o'clock (*maaha*). If the shadow increase by foot length, the time marginally increase by an hour until the evening is dawn. They then greet in the evening as *maadwo* (good evening). In the morning before sun rise, they greet *maakye* (good morning) showing beginning of the day and express good wishes for the day blessed by *Odomankoma* (the Creator).

Table 4.7a gives Akan concept of time and their timeline expressions that can support the teaching of school mathematics on time and modular arithmetic.

Table 4.7a: Akan expression in Time lines (Bere/mmerɛ)

Time lines (Bere/mmerƐ)				
Cardinal number	*Hours (dɔnhwere)*	*Minutes (sima)*	*Seconds (pƐre/anibɔtƐtƐ)*	*Time in hours (nɔn-)*
1	Donhwere baako	Sima baako	pƐre baako	dɔnko
2	Donhwere mmienu	Sima mmienu	pƐre mmienu	nɔn-mmienu
3	dɔnhwere mminsa	Sima mmiensa	pƐre mmiensa	nɔn-mmiensa
4	dɔnhwere anan	Sima nnan	pƐre anan	nɔn-nnan
5	dɔnhwere enum	Sima nnum	pƐre nnum	nɔn-nnum
6	dɔnhwere nsia	Sima nsia	pƐre nsia	nɔn-nsia
7	dɔnhwere nson	Sima nson	pƐre nson	nɔn-son

Knowledge of time is bounded by ethnomathematics concepts in relation to number and numeration concepts as seen from Table 4.7a. The syllabus suggests the teaching of time and modulo arithmetic. These Akan timing concepts could be used to support any pedagogical activities the teacher might use to teach time concepts. Time conversional equivalence is given in Table 4.7b.

Table 4.7b: Akan Timelines with conversion equivalence

Local Timeline	Description	Estimation in Western unit	Conversion equivalence to minutes	Local timeline to conversion equivalence
Anibotete (pƐre)	Seconds	1 second	60 seconds	Anibotete aduosia
Sima	minutes	1 minute	60 minutes:1 hour	Sima aduosia:donhwere baako
dɔnhwere	hours	1 hour	24 hours: 1 day	Donhwere aduonu-nna: Dako
DapƐn	Days	1 day	7 days: 1 week	Nna-nson:nnaawotwe
nnawotwe	weeks	1 week	4 weeks: 1 month	Nnawotwe-anna: Bosome baako
Bosome	*months*	1 month	12 month: 1 year	Bosome dummienu:Afe baako
Afe	years	1 year	Many years	mfisantene
Mfisantene	Many years	years	10 years	Mfie du

An extension of Table 4.7a to give local Akan timelines conversion equivalence is given in Table 4.7b. The Akan concept of time (bere) view seconds, minutes, hours, days, weeks and years as *anibotete, sima, donhwere, dapen, nnawotwe, bosome* and *afe* respectively. Most Akan communities considers a complete month to be *adaduanan* (40 days). For example, the concept of 40 days (*ada-duanan*) is highly respected to set up celebration of deities and is named *Akwasidae, Fodwour, Benada-Dapaa, Awukudae, Fofie, Memeneda Dapaa* and others.

4.2.4 Counting Illustrations Using Games

In Akan communities, games could be used to illustrate ethnomathematics thinking. An example of strategic games played Akans irrespective of gender and age to entertain them and to think critically to build counting techniques includes pebble in-fox games, pebble picking games and among others *(see appendix E)*. The implications of such games are to build in student mathematical learning concept, develop number sense, and open up the minds for creative reasoning and to build children participation of mathematical learning task. Teachers knowledge and interest in integrating these in teaching is very important in the curriculum implementation process (Nabie, 2011)

According to (D. K Mereku & Mereku, 2013), the Mathematical concepts and skills demonstrated in Ghanaian game can be used to develop activities to teach number facts and also as a practice (or follow-up) activity. The game can help children to practice not only basic number facts but also problem-solving strategies like trial and error, looking for pattern, making and testing hypothesis, reasoning and disproving. The Akans entertainment of such games was not designed by our forefathers for entertainment alone, but to inculcate in children the altitude of learning number facts and reasoning.

Students were asked to play Akan counting games such as pebble-picking games (*bantama-krakuro*) and link it to formal circular permutation concept as seen from Figure 4.9.

Figure 4.9: Pebble picking (bantama-krakuro) games as ethnomath counting techniques

The „*bantama-krakuro*" pebble-picking singing game can be used to teach a wide array of mathematical concepts. The formation itself could be used to teach permutation and combination in a circular formation. Mereku & Mereku (2013) suggest that, „the children can discover another application of the concept of Lowest Common Multiple (LCM) which is taught in primary school mathematics". Students would discover that the total number of moves that an object will make in order to end on the last beat of a rhythm at its original or start point is the LCM of the number of players and the beats in the rhythm.

Students used the Akan ethnomathematics concept in this game in Figure 4.9 and applied permutation and combination in circular arrangement and selections of numbers as done in the formal idealization in the mathematics curriculum. This formation is represented in Figure 4.9. The places where the players sit around a circle in the game is labelled A, B, C, D and E for the purpose of this investigation. The players mark their objects so that they will be easily identified. Figure 4.10 shows the arrangement of six players with number of ways in which they can be arranged in the circular formation for the game start.

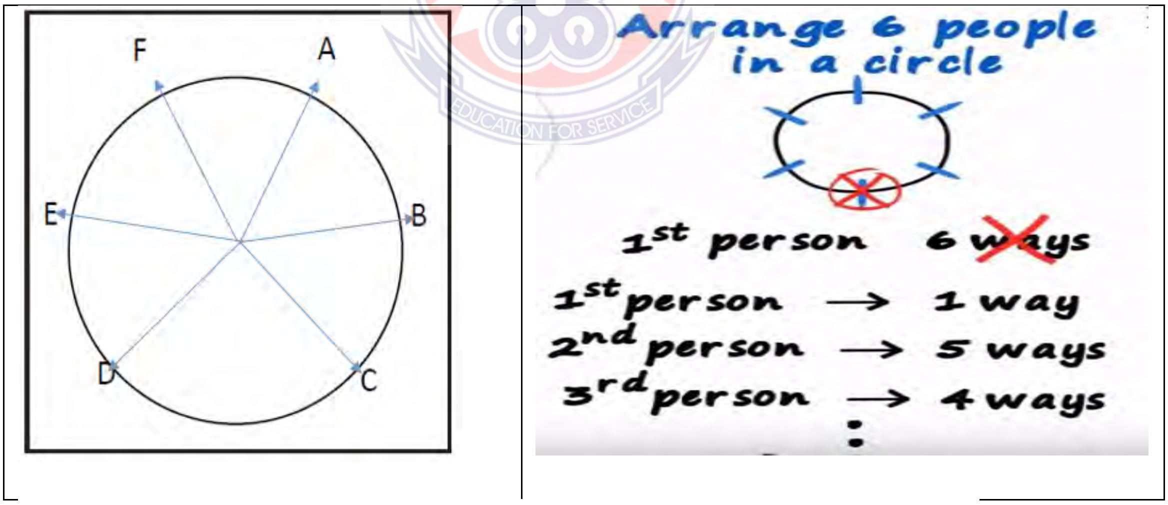


Figure 4.10: Akan ethnomathematics concept of circular formation (of permutation and combination) of sansan-koroma game.

In this investigation, children are helped to find the number of moves an object will make in order to end on the last beat of a rhythm at its original or starting point. This activity in the game creates the concept of circular arrangement called *permutations*. Circular arrangement is a form of permutation in which objects are arranged in a circle. The probability of selecting a player based on characteristics such as failing or wining is called combination. Consider arranging six (6) payers (A, B, C, D, E and F) around the circular formation of the *bantama-krakuro or sansan-koromah* game. To calculate the number of ways in which n objects can be arranged in a circle, we arbitrarily fix the position of one player so that the remaining $(n-1)$ objects/persons can be arranged as if they were on a straight line in $(n-1)!$ Ways. The arrangement for the five players becomes:

$$(n-1)! = (6-1)!$$

This order of circular arrangement would be formed linearly as

$$[abcde, bcdea, cdeab, deabc, eabcd, \ldots]$$

The six players in Figure 9 would have a circular permutation of

$$(6-1)!$$

$$= 5! = 120\ ways$$

The Table 4.8 below shows the permutations of how the game of six players resulted to optimal circular formation until the winner was declared.

Table 4.8: Illustrative Table for permutations of sansankoromah games

n players	No. Eliminated for each round	Permutation $(n-1)!$	$n!$	Possible arrangement of Players in the game
6	1	$(6-1)!$	5!	120
5	1	$(5-1)!$	4!	24
4	1	$(4-1)!$	3!	6
3	1	$(3-1)!$	2!	2
2	1	$(2-1)!$	1!	1
1	1	$(1-1)!$	0!	1

The possible arrangement of the players in the game based on n players is given in Table 4.8 above. The game can start with 6 players who could be arrangement in 120 different ways. As a member of the playing team reduces by 1 as he fouls, the number of players becomes $(n - 1)$ respectively until the optimal winner imerges. Hence the possible arrangement of the players at each respective levels becomes 120, 24, 6, 2 and 1 respectively. Hence the concept of factorial analyses, permutation and combinations as well as other number concepts are clearly specified in this Akan ethnomathematics game.

Akan beads also show how arrangement are made to denote the concept of permutation and combination and other number counting concepts to conform to specific designs and patterns (see Figure 4.11). The beads are also hooked together to form a circular formation to decorate some royals. Some Akan ladies also use the beads for waist building and other bodily decorations. Figure 4.11 display sample of few beads artifacts.

Fig 4.11: Sample of beads with circular, parallel, rhombus and varied ethnomath designs.

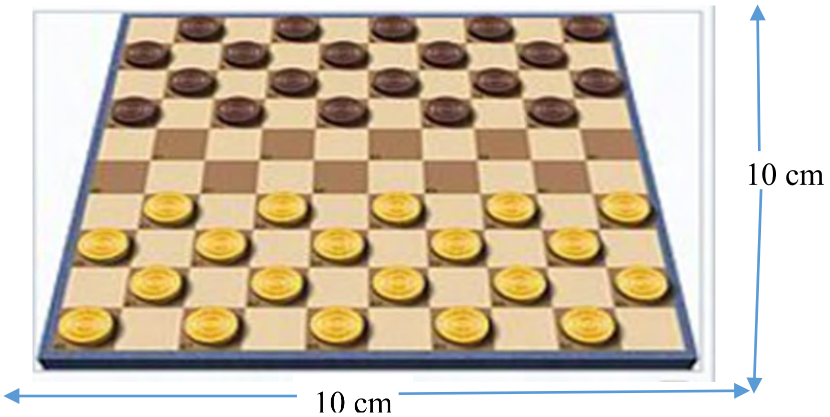
Beads are made in small plastic round pieces baked with holes in it (see Figure 4.11). It needs to be arranged in different patterns for the purpose of its decorations. Akan ethnomathematics is displayed here; where the knowledge of such combination and permutations are applied. Besides, the arrangement of beads by the producer needs to take precautious moves by considering various mathematical thinking of various forms.

From Figure 4.11, the creator of this beads might have taught of various geometrical shapes such as area dimensions of rhombus, squares, parallelogram, parallel lines, circles and some decorative patterns that make them unique. Such materials becomes resource based for teaching mathematical concepts, (Sugianto et al., 2019; Wandari, 2018). Learners becomes curious and interested when such linkages are made to what they know from their culture. This is the belief of the pioneering work of ethnomathematics as a teaching philosophy (Bishop, 2016; D"Ambrosio, 1999; Orey & Rosa, 2016).

4.2.5 Mathematical implication in Draught Game

The ***dame*** (draft/draught) game as it is usually called by Akans is one of the popular thinking-based game traditionally developed and believed to train the mind of the players logically. Gradual exposal of individuals to the game help enrich their experience in life decisions, critical thinking skills, decision making process, train the youth for war tactics, how to read the minds of others etc.

Draughts or Checkers is a strategic board games usually played by two players. The players move the game with ethnomathematics concept of uniform diagonals, (see Figure 4.12). The purpose of the moves is to mandatorily capture wooden or plastic small flat marbles by jumping over opponent pieces diagonally. Akan draught or Dame is a board game developed from square boards hooked identically with pairs of square units packed/glued together. The name *dame* is derived from the verb *to leap on me or draw to move.*



$$total\ area = 10 \times 10 = 100\ square\ units$$

Fig. 4.12: The Akan Dame game layout for starting

The Akan Dame conforms to international draughts standard, played on a 10×10 game board as seen from Figure 4.12. Draughts is played by two opponents; one sit opposite to game board and vice versa. One player takes the dim pieces; the other also takes the light pieces. Players alternate turn naturally as the won marbles exchanges to the opponent. A player should not move an opponent's piece. A move of the square units is directed diagonally to an adjacent unoccupied square pace. If the adjacent square contains an opponent's piece, and the square immediately beyond it is vacant, the piece may be captured (and removed from the game) by jumping over it severally to win all piece. The players only use the dark squares of the dame board. In the game play, capturing is a mandatory rule, although some rule varies making capturing optional. In almost all variants, the player who losses all his remaining pieces or who cannot move due to being blocked, loses the game. If an opponent manages to maneuver through to the last lane of his opponent, the marble turns to be *akorɔma* (eagle) who can fly to any diagonal point to capture opponent‟s marbles. The *akoroma* usually allows the opponent to win more pieces faster and can aid in winning.

The mathematical implication dame presents is the concepts of geometrical shapes of squares mathematically counted as:

$$Total\ square\ of\ pieces\ overlap\ (10 \times 10) = (100 + 1) squares\ units$$

$$Number\ of\ square\ pieces = 20 + 20 = 40\ pieces.$$

$$Probability\ of\ winning\ is\ ½\ or\ draws$$

$$Total\ number\ of\ rounds\ of\ wining\ opponent = 5\ rounds$$

$$Total\ average\ area\ dimension\ for\ dame\ game (in\ metre) = 0.7m \times 0.7m$$

$$= 0.49m^2$$

$$Area\ of\ each\ marble\ piece = 0.07 \times 0.07 = 0.0049m^2$$

$$Total\ area\ of\ marble\ pieces = 0.0049(20 + 20) = 0.196m^2$$

The results are summarized in the Table 4. 9 below

Table 4.9: Ethnomathematics on Akan Dame game

s/n	***Description***	***Computation***	***Results***
1	Total square pieces overlaps	10×10	100 unit squares
2	Total marble pieces	20×20	40 pieces
3	Probability of winning	$\left[\frac{1}{2}, draw\right]$	$\frac{1}{2}\ or\ draw$
4	Total round set for winning	$5\ per\ 1 game$	5
5	Average area for Dame game	$0.7m \times 0.7m$	$0.49m^2$
6	Area of each marble piece	$0.007m \times 0.007m$	$0.196m^2$
7	Number of Players	$2 \times 1\ game$	2

The creative thinking and probability measure of wining is a major achievement. There is also a natural urge to accept losing and coming back to win. This application to mathematics problem solving stages is good for student. This according Mason (1992) problem solving model is referred to as three phases; planning stage, attacking stage and looking back stage, (Mason, 1999). Students do not fear to attack mathematical problems, neither do they get discouraged when they lose the opportunity to solve it. There is this intrinsic motivational characteristic attached to the Dame game. Akan belief that the moment you go to *dame-dua-ase* (meaning three shadow of draught), one gets total commitment and even to the extent of disowning responsibilities. The game initiate both intrinsic and extrinsic form of motivation to tackle, observe and think deeply for any reasonable moves. Failure to do so, opponent begins to render insult to draw opponent"s attention.

The game as already introduced shows Akan peoples ethnomathematics way of thinking and reasoning, believed to train the mind of the players. Gradual exposal of individuals to this dame game would help enrich their experience in life decisions, critical thinking skills, decision making process, train the youth for war tactics, how to read the minds of other, etc. the game can be used to teach probability, areas of rectangle and squares

4.2.6 The Oware Game and its mathematical implication:

It is one of the famous and popular Akan games that has ethnomathematics implicative to the teaching and learning of mathematical concepts. It possesses the ability to recognize numbers, conceive natural counting in base four (since the marbles must be started and won on the bases of four counts) and among other criteria set for winning the game.

The oware game is played popularly among many Ghanaian societies, especially among the Akans. In as much as it is used as a means of entertainment, social interaction, and among others, it also trains the intuitive mind. It was used as a means of training children how to count, process information, and has ethnomathematical construct believe to open the minds of the people for reasoning. It has the concept of addition, subtraction division and multiplication of marbles. The concept of numbers is illustrated ethnomathematically.

The *Equipment and Initial Setup of the game demands six opposite pairs of holes in the ground or drilled from flat wood.* To play *oware abapa* as most Akan communities call it, you will need a game board (in the absence of this is a drilled hole on the ground) and forty-eight game pieces, which are so-called seeds of cowries or pebbles or palm kernel pebbles. Usually, the board consists of two rows of six holes located at opposite sides. Two larger holes on the sides of the board are used to store the seeds players capture during the match. It is said that the bottom row belongs to the player who moves 1st, named south, and the upper row to the second player or north.

Oware board in its starting position, each of the playing holes contains exactly four seeds. In the starting position, each hole excluding the two largest ones (stores) contains exactly four seeds. In this position the south player will make his 1st move, followed by a move by the north player and so on until the game ends. Figure 4.13 below shows how the game is outlined for a start.

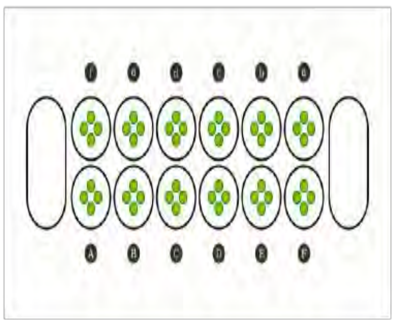


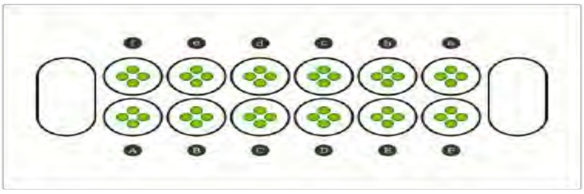
Figure 4.13: The traditional Oware Board and its starting layout

The oware game as seen from Figure 4.13 also visualizes ethnomathematics number and numeration concepts that is good for counting, place value concept for number base four, and other operational algorithm such as addition, subtraction, multiplication and division.

Goal of the Game: The goal of oware is to capture the greatest number of seeds as possible to conceive on numbers of counting and base four algorithm. To do so, players make moves in alternate turns until one of them has captured more than 24 seeds. The player who captured more seeds than his opponent when the game ends wins the match. It may also happen that both players have captured the same number of seeds at the end. In this case, neither player wins the game nor the match is said to have ended in a draw.

Students Activity in Playing the Game: Students were put into groups to play the oware game by recognizing its rules and creating a linkage of counting in base four. Each move of the game is done in three phases: collecting, sowing and capturing. During the sowing a player distributes the collected seeds along the board, and during the capture phase the player takes, if possible, the seeds found in the pits of the opponent. A seed is collected in the 1st phase of a movement, the player who is to move chooses one of the holes on his own side of the board and collects all the seeds on it, leaving the hole empty. Subsequently, these seeds will be distributed on the board during the sowing phase. A player may collect the seeds from any of the holes that belong to him if it contains one or more seeds, only with the exception that after making the move his opponent must be able to play. Therefore, a move that would leave all the holes empty on the opponent's side is not legal.

Sowing Seeds: During sowing, the player distributes the seeds collected in the first phase along the board in a **counterclockwise** direction; dropping **one seed** in each of the playing holes until all the seeds are distributed. A player will never sow on the holes used for storage.



Sowing process in oware: South sows 4 seeds, distributing them around the board one by one in a counterclockwise direction. After sowing the seeds, the hole from which the player has collected seeds will be empty. It may well be the case that the player sows twelve or more seeds, in which case the player will show them going round around the board, dropping one seed in each hole in every round, but never dropping a seed in the hole from which the seeds were collected.

Capturing Seeds: When the last sown seed is dropped in one of the holes belonging to the opponent, and after dropping the seed the hole contains exactly two or three seeds, the player will capture them. Taking all the seeds from the hole and saving them in his own store. When the hole immediately to the right of the last pit from which seeds were captured contains also two or three seeds, the player will capture them too. And so on until the player cannot capture more seeds, always taking into account that players can only capture seeds from their opponents" holes and never from their own holes. After sowing three seeds, collected from the F hole, south captures 5 seeds from holes" b and c. Note that a player can never capture all the seeds of the adversary. If a player makes a move that would capture all the seeds on the opponent's side, that player will sow normally but will not capture any seeds.

End of the Game: Typically, the game is over when one of the players has captured more than 24 seeds or when both of the players have captured 24 seeds. It may also happen that a player cannot make any legal move

The Key content and mathematical construct/concepts illustrated by the Ludo and oware games has long been used as an intuitive method of conserving number and numerations concepts. They possess the ability to recognize numbers, conceive natural counting in base four (since the marbles must be started and won on the bases of four counts) and among other number pattern concepts. We drill on the type of number concepts the game might suggest such as natural numbers, counting numbers, even numbers, odd numbers, integers, prime numbers etc.

The oware game give intuitive lesson by allowing students to compare the formal number and numeration representations to the informal traditional/indigenous application of number concepts and how they were conceived through instinctual games in oral tradition.

Application: An application of this game would help students to be able to use the knowledge gained from their traditional games to appreciate the mathematical implication of indigenous number theory games found in their communities. They can arbitrarily generate number symbols to rebrand the oral tradition to the most formal approach which could later be considered in curriculum development in Ghana.

Finally, mathematical games provide the child with enormous opportunities to develop his or her ability to reason mathematically. The desire to win a game put both players under pressure. Some mathematics educators who understand the role of games in mathematics metacognition (Jiang, Xiao, & Xiao, 2016; Langdon, 1989, Mereku & Mereku, 2013) identified several mathematical processes associated with ethnomathematics game-play. Children undertake certain mathematical processes such as visualisation, recognition to counting systems associated with the number of stones in each hole; be aware of, and anticipate set formation and recognition such as empty set; count back from a possible finishing hole in order to recognise a good starting hole; use rotational symmetry; anticipate the effect of a move on the opponent; plan ahead; and reject poor possibilities and eliminate positions which are vulnerable to the opponent. These abilities, according to (Mereku & Mereku, 2013) are the foundations of a child‟s development of mathematical thinking before encountering the formal mathematical concepts. Children understanding of higher-level mathematics would be limited unless he or she has had the opportunity to develop these basic abilities through series of ethnomathematics games.

4.2.7 The Figure Counting techniques

Akan sometimes use other gesture means to connote informal operation of sums and differences such as figure counting techniques. Figure 4.14 also shows how the figure counting system is used traditionally to induce number and numeration concept with means of operation. This is typically good for primary number operation teaching especially when formal addition algorithm materials are not there.

Figure 4.14 shows the figure counting techniques in counting cardinal numbers and operating sum of numbers.

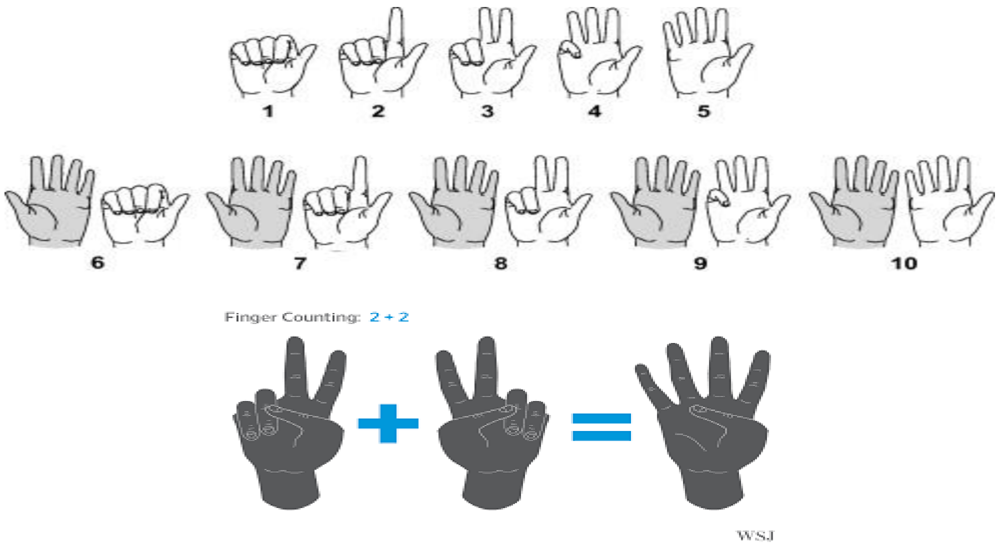


Fig 4. 14: Figure counting techniques and operational sum

The figure counting system has long been used by many traditional Africans for arbitral counting and number operations especially within single digit and two-digit number additions and subtractions. Finger counting is a form of Body Counting method used to describe magnitudes of a system. Body parts, according to (Weibull, 2013) are associated with a given quantity and by touching them, the given quantity is inferred. It can be as limited to the ten fingers or as advanced as upwards of forty different parts of the body. Again, this system is constrained to a fixed limit, yet is an advancement over both types of 2-count (Weibull, 2013).

The body movement comes in the form of sensorimotor, perceptive and kinaesthetic-tactile experiences are few fundamental for the formation of mathematical concepts for even highly abstract ones connected to formal mathematical concepts. The key role attributed to the use of fingers in the development of number sense seems to be highly resonant with the frame of *embodied cognition*. Fingers and hands naturally embody part-whole relationships with respect to basic number operations can and should be used to foster such awareness of number operations. The didactical potential of hands and fingers in their natural positions can be exploited in many different ways. This may include multi-touch technology, well before formal schooling starts, humans adopted some counting systems of measurable numbers through body language (Swetz, 1989; Tessa, 2001)

4.2.8 Akan ethnomathematics based on naming

Akans naming of their new borne babies also follow ethnomathematics counting system. For example, the naming of Akan children names is based on ethnomathematical illustrations of number counting techniques. Table 4.10 below some examples of number concepts found in Akan names;

Table 4.10: Akan ethnomathematics base on naming

Names	Meaning	Ethno-numeration	No. concepts
Ahenkan	First royal son	Baako (kan/koro)	1
Odikuro	The first man/leader	Baako/koro	1
Manu	Second male born	Mmienu (baanu)	2
Maanu	Second Female born	Mienu (baanu)	2
Mensa	Third male born	Mmiensa (abaasa)	3
Mansa	Third female born	Mmiensa (abaasa	3
Anane/anane	Forth male/female born	Anan (Ɛnan)	4
Anum/Anumwaa	Fifth male/female	Nnum (enum)	5
Nsia/Nsiaa	Sixth male/female born	Nsia (asia)	6
Nsowaa	Seventh male/female born	Nson (ason)	7
Nnwotwewaa	Eighth female born	Nnwotwe (awotwe)	8
Nkromah	Nineth born	Nkron (akron)	9
Badu/Badu	Tenth born	Edu (du)	10
Duko/Aduako	Eleventh male/female born	Du-baako (edu+koro)	11

Table 4.10 shows the sequence and series of Akans births with pattern names to reflect numbers concepts. Ethnomathematics philosophers are of the view that, when the culture of the people is brought to the formal instruction encounter, meaningful lesson is achieved, (Aikpitanyi & Eraikhuemen, 2017; Alfarisa & Robiansyah, 2019; Barton, 1998; Oliveras, 2000; Rosa & Orey, 2009). It is better to mention Akan name in exemplifying mathematics problems of any topic rather than using foreign naming that could confuse the students.

Students used the palm length as arbitral units to measure the length and breadth of their table, marker board and classroom. Akans use such ethnomathematics in measurement of houses plots, land, wood, trap and among others.

4.2.10 Concept of Area and perimeter

Area literary means an amount of space an object can occupy. In most Akan communities where farming triumph, farmers make ridges and mounds as seen from Figure 4.16 below.

Figure 4.16: Akan Area dimension in farm land

In order to measure the area of farm land, some Akan people mound yam mounds or ridges that stretches length by breadth through *anamon* and *basafa* measurement. The number of mounds made is counted from the width side and length side respectively for calculations to be made. For 20 by 30 mounds on a rectangular field, it is expected that

$$20 \times 30 = 600\ mounds$$

would be made. Majority of the sampled farm land had area bounds ranging from 600 to 12,000 yam mounds.

4.2.11 The use of Folktales:

The use of Folktales could support the teaching of some mathematical words problem, (Amit & Quoder, 2017). Socio-cultural values, traditions, and symbols are demonstrated in the social life of every group of people. Education in general and mathematical education, in particular, is also affected by cultural values. The integration of folk-stories adapted from traditional folktales systems according to, (Abu Qouder Fouze & Amit, 2018b) helps bring students understanding on words problem. We can also implement the mathematics curriculum by integrating cultural and folkloric elements and values from the daily life of students, including folklore stories. These can contribute to increase student motivation to study mathematics, which in turn increases their academic achievements in the subject. An Example of a Folk Story that Contains Mathematical Values and that can be used to Aid the Instruction of Mathematics (adapted from Fouze & Amit, 2018) is given below:

> ***Illustrative folktale***: "On Ananse‟s birthday, his grandmother cut 12 pieces of ofam (cake), after he told him that he had invited twelve friends. However, only two friends arrived on time, and the rest came later".
> ***Question 1***: If Ananse wishes to divide the 12 pieces of cake between his son Ntinkumah and himself, how many pieces of cake would each receive?
> ***Question 2***: If we had 16 pieces of cake and four boys, can we divide them equally between them?
> ***Question 3***: As we have six friends and 12 pieces of cake, how many pieces does each child receive?

Participants reacted to the solution of these mathematics word problem as easily as possible. This confirms suggestion of people mind-set that are easily shaped by the influence of known cultural elements, (Azmi & Wardono, 2018). Some of these folktale illustrations even serve as recreational mathematics that support the teaching and learning with intrinsic motivation and logical reasoning.

4.2.12 Puzzles and Recreational Ethnomathematics

It is useful to distinguish another subclass of Akan ethnomathematics problems called puzzles. A puzzle is a particular type of problem that usually requires little prior mathematical knowledge. There have been attempts to define puzzles, for instance as tasks requiring „lateral thinking" (De Bono, 1971). For example (Michalewicz & Michalewicz, 2008) suggest that the nature of an (educational) puzzle is encapsulated by four criteria: generality (explaining some universal mathematical problem-solving principle), simplicity, a creative thinking factor and an entertainment factor. To the Akans, a puzzle is a question that is free-standing (requiring little or no prior knowledge), lightweight (lacking gravitas and without ramifications), connecting to the participant ability to recognize creation and environment and needing imagination to solve it. Frequently, such ingenuity will be in the form of a trick or sudden insight, providing the „*Eye den" (it is difficult)* factor as commonly mentioned in Akans. A mathematical puzzle need not have wider impact on mathematical knowledge, or be part of a circle of ideas; it can be happily self-contained. Sometimes, however, there are useful principles involved, or techniques that can be stored up for future use.

Participant was asked to give some examples of puzzles and recreational mathematics from Akan ethnomathematics perspective that best open the minds of the people. Quite a number of participants suggested a resolution to this problem:

A man travelling with goat, tame lion and a yam want to cross a bridge. If the canon could pick only one item with the traveller at a time, how can the traveller cross the river with all his items unhurt?

Paraphrasing this into logical mathematical terms to check their level of reasoning as seen from the following interview:

Researcher:	Do Akan riddles and puzzles project mathematical reasoning?
Focus 3:	Yes of course!
Researcher:	Can you give me one example?
Focus3;	Yes
Researcher:	Okay! Lets go
Focus 3:	A man was travelling with three (3) items namely goat, tame lion and a yam. He want to cross a bridge with a canoon that can take only one item including himself. If the canoon can pick only one items with the traveler, how can the traveler cross the river with all his items unhurt?
Researcher:	Wow!, That"s cool!. Good. Do you know the answer? Tell me then…
Focus 3:	Yes! The man has to take the goat first since lion can"t eat yam, he then comes to to take the lion second but have to take the goat back again to the other shore where the yam was. He then take the yam back to where the lion is and leave…he then come back to take the goat along.
Researcher:	Wow!. That"s good. You reason well.
Focus 3:	It was my grandmother who used to give us such stuff…., you know
Researcher:	Can I give you a riddle just like yours but more mathematical to try?
Focus 3:	Okey!
Researcher:	Three men want to cross a river. They find a boat, but it is a very small boat. It will only hold 200 pounds. The men are named Okese, Honeho and Ketewa. Okese weighs 200 pounds, Honoho weights 120 pounds, and Ketewa weighs 80 pounds. How can they all get across? They might have to make several turns in the boat.
Focus 3:	Yeee!, the boat can take 200 pounds? ok. Let me try*…(She uses a similar reasoning for her riddle and at the long struggling, she manage to produce the answer)*
Researcher:	That"s good. Would this knowledge in Akan ethnomathematics help one studying mathematics in the formal classroom?
Focus:	Yes. It involves a lot of reasoning and calculations.
Researcher:	That"s good!

This interview with the participant was to find out whether they have knowledge for mathematics in their recreational tales, riddles and puzzles. The participant used mathematical reasoning search to develop understanding in describing her performance. Upon hearing the instructions, she immediately asked "The boat can hold only 200 pounds?", and the researcher answered affirmatively. Thereafter, almost all of her discussion of the puzzle used only "sail" as a main verb and "*Okese", "Honeho", "Ketewa*", "the boat" and pronouns as noun phrases. Her complete protocol in reasoning along the semantic connotations of the question was resolute. Creative thinking and reasonable decision needs to be arrived. It is apparent from the protocol that the participant solves this problem by imagining the physical situation leading to meaningful reasoning. To the Akans, any phenomenon that leads to critical reasoning create a form of mathematics, (Bannister, Davis, Mutegi, & Thompson, 2017; Davis, 2017).

The psychological implication of teaching mathematics demands that teachers exemplify mathematics problems by considering the creation of their problems to conform to the child immediate environment and culture. Mathematics educators need to understand the essence of ethnomathematics as a form of naturalistic approach in which mathematics pedagogies could be adopted.

4.3 Research Question 2:

How do Akan Ethnomathematics (informal) reveals/connects School- based curriculum mathematics (formal) teaching and learning?

This section reports a survey on Akan ethnomathematics concepts and its interconnection with the formal school-based curriculum in the teaching and learning process. Discussion of how informal Akan ethnomathematics is seen from tradition and arbitrary mathematics connotations as a bases of teaching formal mathematics systems is reported. Data analyzed constituted field observation of Akan artifacts, ethno-technology and in some occasions, interview guide to study participants.

4.3.1 School mathematics Organization and some Akan ethnomathematics activities

The school mathematics, from primary level to secondary level of the child‟s education is organized around certain mathematical content strands in the curriculum. These strands organization revolves around number and numerations plane geometry, mensuration (area, perimeter and volumes), algebra, statistics and probablity, trignometry, vectors and transformations in a plane as well as problem-solving strategies associated with them.

In the Ghanaian Senior High School for instance, the structure of the syllabus is organized within the first three years with these strands. To determine how basic ethnomathematics activities support the development of mathematical concepts in the school mathematics curriculum, the researcher carried a content analysis on the syllabus. Table 4.11 shows the strands (contents) from the formal SHS mathematics curriculum, level to be taught as well as links to basic ethnomathematical activites that support the teaching of school mathematical concept formation for the respective standards.

Table 4.11: School mathematical standards and Akan Basic supportive Ethnomath

s/n	Strands of Curriculum	School level	Basic Ethnomathematics Activities and mathematical concept	Mathematical Concepts they support
1	Numbers and Numeration.	SHS 1 &2	1. Finger counting 2. Oral numeration 3. Debt tallying 4. Counting-based games	Number and counting system from the informal perspective, grouping, ordering, sorting etc
2	Plane Geometry	SHS 1, 2 & 3	1. Production of mats, tables and stool chairs 2. Measurement through foot and finger length and arm 3. Measurement of land for Farming, fathom 4. Demarcation of plots and lands	Measurement of Length and Distance
3	Mensuration	SHS 1, 2 & 3	1. Area and perimeter of home-based artefacts 2. Volumes of pots 3. Construction of indigenous circular technology 4. Earth-ware bowls	Area volume, capacity
4	Algebra	SHS 1 & 2	1. Sales 2. Riddles and puzzles 3. Games, eg. Drafting	Abstractions, logical reasoning
5	Statistics and Probability	SHS 2&3	1. Counting systems 2. Grouping and sorting things 3. Arrangement in ascending or descending order 4. Tracing and drawing emblems 5. Tallying for debts 6. Games (draft, Ahyehyeaba, peele)	The body of numbers and the possibility of occurrence of events
6	Trigonometry	SHS 2&3	1. Indigenous building technology 2. Craft and designs 3. Weaving (kente, mats, aserenne, Adwokuo) 4. Farm practices	Distance apart, turnings as angles, traditional indigenous technologies. Eg. buildings
7	Vectors and Transformation in a plane	SHS 2&3	1. Dancing 2. Translation 3. turning about points 4. games 5. length	Translation, Bearings, rotation, enlargement, reflection, similarities
8	Problem Solving	SHS 1, 2 & 3	1. Storytelling 2. Riddles and Puzzles 3. Role-playing	Recreational mathematics

From Table 4.11, an interconnection of basic Akan ethnomathematics activities are paralleled with formal school mathematical content strands through content analyses from the suggested syllabus with field observation. The teaching of Numbers and Numeration is structured to be taught within the SHS 1 and 2 academic years. Some basic Akan ethnomathematics activities supporting cardinal number concepts and numerations were observed to include finger counting, oral numeration, stroke for debt tallying, cardinal counting system from the informal position with respect to place value recognition as well as naming techniques and among others.

Plane geometry is organized to be taught at SHS 1, 2 and 3 respective classes. These concepts are seen to connect Akan‟s ways of Producing mats, tables and stool chairs. In addition, Measurement using various fathoms such as foot counting, finger length stretching and arm length stretching helps to arbitrary estimate lengths, distances and perimeters of surfaces. Other practices such as measurement of land for farming, demarcation of plots and lands and measurement of length and distance are practice to connote their knowledge in geometrical applications.

The concepts of area, perimeter and volumes are learnt under the mensuration topic structured to be taught at SHS 1, 2 and 3 respectively. These formal concepts are also found in Akan ethnomathematics practices. These take the form of measurement of area and perimeter of plot of lands. Ethno-technology of home-based artefacts support the recognition of volumes of pots in their various shapes and form to connote capacity. The construction of indigenous circular technology like earth-ware bowls suggest the application of the recognition of the concept of pi, area, volume and capacity as measured in *Apotoyoa, suhina, yaawa* and among others. Many ethnomathematics researchers have investigated into various indigenous African ethnomathematics to revolve around application to geometry. The Akan ethnomathematics has a lot of equal geometrical application of formal mathematics systems. The teaching of Algebra is also structured to be taught in SHS 1 and 2 the concepts of set and logic is found in Akan concepts of market sales, riddles and puzzles, games such as drafting to make deep abstractions in logical reasoning.

The teaching of Statistics and Probability is to recognize the need of data collection, analyses and estimation of chances of occurrence of events (NaCCA, 2019). The topic on probability and statistics is organized to be taught in the SHS 2 and 3. Some Akan ethnomathematical practices to recognize this, involves tallying concepts used to mark debts called *sandanho*, various counting activities, grouping and sorting things, arrangement in ascending or descending order, tracing and drawing emblems. Games such as draft, Ahyehyeaba, peele are designed to help build children and adults way of thinking and chance of winning or losing. The body of numbers and the possibility of occurrence of events are seen to have a common connection to formal and informal idealizations.

Similarly, Trigonometry is taught in SHS 2 and 3 to build students understanding of geometric measurement and angles. Akan application of this concept is seen in their indigenous building technology such as masonry and carpentry. In addition, craft and designs, weaving (kente, mats, aserenne, Adwokuo), farm practices and among others are designed to investigate distance apart and turnings as angles.

Vectors and Transformation in a plane is to be taught in SHS 2 and 3. Akan adopts dancing moves and skills to show translation of gestures such as Akan *adowa* dance. Concept of vectors and bearings help learners to recognize translation, turning about points, bearings, rotation, enlargement, reflection and recognising similarities. Problem solving strategies is designed for all the topics to help learners reflect on their problem-solving thinking skills in application and evaluation of mathematical concepts for all levels of the child"s education. Akan use storytelling, riddles and puzzles, Role-playing as a form of Recreational mathematics.

To further establish the interconnection between Akan basic ethnomathematics activities with the formal school mathematics, students were asked to associate their understanding of certain formal mathematical concepts to some Akan ethnomathematics surveyed. Table 4.12 shows students" response to whether they recognize the interconnections between selected basic Akan ethnomathematics to school-based mathematical concepts or not. The number and corresponding percentage of response (yes or no) is organized in Table 4.12.

Table 4.12: Students response to whether teachers interconect Akan basic ethnomathematics with school based mathematics teaching.

	Basic Ethnomathematical Activities	School-based mathematics standard concepts	Yes	No
1	Number and numerations (*Nkontabudeɛ*)	Shape and space	56 (65.1 %)	30 (34.9%)
2	Measurements (*Nsatea, nsayem, basafa. Anamon, nsatremu, kwansin, kwantenten*)	Measurement of length and distance (unit and dimensions)	67 (77.9%)	19 (22.1%)
3	Set ethnomath (*aboaboa, boa*)	Set, logical reason	50 (58.1%)	36 (41.9%)
4	Akan Algebra connotations (*biribi, ebi, nyinaa, nohoaa*)	Algebra concepts	26 (30.2%)	60 (69.8%)
5	Geometric-based games	Geometry, polygons, area and perimeters	54 (62.8%)	32 (37.2%)
6	Geometric-based Artefacts (earth bowls wares)	Geometry, volumes, capacity area and perimeters	58 (67.4%)	28 (32.6%)
7	Asanka concept of pi (circular ethno-technology)	Mensuration (concept of pi)	70 (81.4%)	16 (18.6%)
8	Foot and Hand counting	Perimeter and area measurement	45 (52.3%)	41 (47.7%)
9	Geometrical artifact (*Kɛtɛ, asrɛnɛ and mukyia*)	Geometry (rectangles, Rhombus, similarity and congruence	26 (30.2%)	60 (69.8%)
10	Game-based (Ludo, die rolling, *oware*, *dame*)	data collection, area measurement, perimeter	54 (62.8%)	32 (37.2%)
	Total number of students		86 (100%)	

The exploration of Akan ethnomathematics activities and its interconnections with the formal school mathematics is explored from field observation and content analyses is made. Students" response to yes or otherwise is given in Table 4.12.

The Akan referred to the concept of number and numerations as (nkontabudeɛ) which was observed to have interconnections with the Hindu-Arabic numeration system with respect to cardinality and place-value concepts. Student yes response associated with this was 56 constituting 65.1 % whiles no response was 30 representing 34.9%. Akan concept of measurements is based on the activity of using the little finger length for inch, arm length, leg stretching, arm stretching referred to as (*Nsatea, nsayem, basafa. Anamon, nsatremu, kwansin, kwantenten*) for the arbitrary measurement of length and distance (unit and dimensions). Yes and no response to this recognition of the interconnection were 67 (77.9%) and 19 (22.1%) respectively.

The concept of set is seen from Akan ethnomathematics perspective as (*aboaboa, boa*) for the act of grouping things together in their unique likeness. Set helps in logical reasoning. Students yes and no response to this recognition of the interconnection in this exercise were 50 (58.1%) and 36 (41.9%) respectively. Similarly, Akan Algebra connotations (*biribi, ebi, nyinaa, nohoaa*) helps to connote algebraic concepts of thinking in abstractness. Students *yes* and *no* response to this recognition of the interconnection were 26 (30.2%) and 60 (69.8%) respectively.

Akans normally use geometric-based games designed to entertain and to help children recognize shapes, size, angles, geometry, polygons, area and perimeters. Students who realized the interconnection with valid yes response were 54 (62.8%) as opposed to those with invalid no response of 32 (37.2%). Geometric-based Artefacts that are designed in the form of earth bowls wares called *apotoyowa* also interconnect formal geometry, volumes, capacity, area and perimeters. Students yes and no response to this recognition of the interconnection were 58 (67.4%) and 28 (32.6%) correspondingly. Geometrical artifact such as mat *(KƐtƐ),* Stretched mat *(asrƐnƐ)* and firewood-tripod brassier *(mukyia*) -Geometry (rectangles, Rhombus, similarity and congruence 26 (30.2%) 60 (69.8%). Game-based (Ludo, die rolling, *oware*, *dame*) are used for entertainment and data collection, probability, perimeter and in some occasions area measurement. Number of students *yes* and *no* response to this recognition of the interconnection were 54 (62.8%) and 32 (37.2%) respectively.

Akan popular kitchen dish bowl called *Asanka* and its various form have accurate estimation of concept of pi (π) measured from circular ethno-technology. This is deemed to support the teaching and learning of mensuration topic. Students *yes* and *no* response to this recognition of the interconnection on it were 16 (18.6%) and 70 (81.4%). Foot and Hand counting techniques are basic ethnomathematics activity used to measure perimeter and area. Students‟ *yes* and *no* response to this recognition of the interconnection were 45 (52.3 %) and 41 (47.7%) respectively.

In conclusion, making a connection of ethnomathematics to school mathematics is understood by majority of the students. Mathematics educators who establish a connection of ethnomathematics with school mathematics normally help students to understanding the formal application of school mathematics.

4.3.1 Akan Number concepts, Numerations and counting system

Akan concept of number recognition is predominantly based on Language spoken and transmitted orally. Language is indispensable communication too for human existence. The bases of language communication dissociate man from other living organisms on the surface of the earth. Communication of thought brings out the cognitive ideas inherent in human‟s knowledge. Akan‟s communication system and education systems are predominantly based on oral traditions. Preservation of number concepts for instance tell a lot about the extent to which Akans know mathematics before the arrival of white man‟s educational system called formal education, (Shapiro, 2001). We explore in this section, an investigation into the extent to which Akan language system in the form of their communications suggest their knowledge in ethnomathematics of number concept.

Number and numeration are the introductory topic (strand) in almost all levels in pre-tertiary education. The idea of counting system among the Akan people suggest the natural base ten algorithm. The researcher found that the concept of counting system and numerals are explained while asking question to different Akan people. The Akan people mostly use their native counting system (which is in practice from long period of time) called *nkontabudeƐ* (numerals). The researcher observed that there is no written record of Akan concept of number and numerations. Such mathematical ideas and conceptualization were transmitted through oral tradition before they were enlighten into formal education systems. The Akan informal ethnomathematics numeration concepts are counted based on place-Value of ten, i.e. ones, tens, hundreds, thousands and tens of thousands, hundreds of thousands, million up to any finite or infinite move of counting systems seen from the formal types, i.e.

$$1, 2, 3, 4, 5, 6, 7, \ldots, \infty$$

If knowledge of formal system had been given attention to by traditions, a richer mathematical numeration concept could have been obtained. Hitherto, Ghanaian students‟ knowledge of this helps to understand number and numeration systems.

In the Akan numeration ethnomathematics, *baako* represents ones as initial digit place value. Tens denotes *edu*. After ten counts, the place value is felt in aditional connotations of the initial counting systems as *du-baako*, *du-mmienu, du-mmiensa*, etc. on reaching 20, the after value similarly continue as *aduonu-baako, aduonu-mmienu, aduonu-mmiensa*, etc. these continue into *aduasa (30s), aduanan (40s),…, aduonnum(50s),…, aduosia (60s),…, aduoson (70s),…, aduowotwe (80s),…, aduakron (90s),…, ɔha (100),* etc.

From Table 4.13, an illustration of Akan numeration is done orally to connote the place value of Hindu-Arabic numeration representation. Even though, counted orally, the natural base ten is best illustrated in ones, tens, hundreds, thousands, tens of thousands, hundreds of thousands, one million, hundreds of millions, tens of millions, hundreds of millions, one-billion, tens-of-billions, hundreds-of-billions, one trillion and so forth. This is illustrated in Table 4.13 where a comparison of the formal numeration place value structure to the Akan informal illustrations is given.

Table 4.13: Place-value concepts of Formal mathematics and informal Akan ethnomathematics systems

Illustrative example	*Place Value (Formal Illustration)*	*Place-value (Informal Illustration)*
1	Ones	Baako
10	Tens	Edu-so
100	One Hundreds	ɔha-so
1000	One Thousand	Apem
10,000	Ten Thousands	Mpem-du
100,000	Hundred Thousands	Mpem-ha
1,000,000	One million	ɔpe
10,000,000	Ten millions	ɔpe-du
100,000,000	Hundred millions	ɔpe-ha
1,000,000,000	One billion	ɔpe- pe
10, 000,000,000	Ten billions	ɔpepe-du
100, 000,000,000	Hundred billions	ɔpepe-ha
1,000, 000,000,000	One trillion	ɔpe-pe-pe
10, 000, 000,000,000	Ten trillions	ɔpe-pe-pe du
100, 000, 000,000,000	Hundred trillions	ɔpe-pe-pe ha
1,000, 000, 000,000,000	One quadrillion	ɔpe-pe-pe-pe
…	…	…

From Table 4.13 the Akan language system in the numeration part of speech represent their knowledge in mathematics in the form of oral counting. Any number representation of the Hindu-Arabic formal representation was seen to be equally represented in the Akan informal numeration. Counting system seen from Table 4.13 sequences to infinite count of numeration to match the place value system illustrated in Table 4.13

Student interview below shows Akan people counting system knowledge of numbers reading, speaking and writing base on generic skills they acquire.

Researcher:	Do you know how to count numbers 1, 2, 3,…,100 in Akan Language?
Respondent:	Yes
Researcher:	Count for me
Respondent:	Baako, mmeinu, mmiƐnsa, anan, enum, nsia, nson, awotwe, nkron, edu, du-baako, dumienu, du-miensa, du-nan, du-nnum, du-nsia, du-ason, du-nnwotwe, du-nkron, aduonu, aduonu-baako, aduonu-mmienu, …, aduasa, aduasa-baako,…, aduanan, aduan-baako,…, aduonum, aduonum-baako,…, aduosia, aduosia-baako, …, aduoson, aduoson-baako,…, Aduowotwe, aduowotwe-baako,…, aduokron, aduokron-baako,…, ɔha
Researcher:	Can you read these numbers for me in Akan numeration? (i) 10,133 (ii) 24,510,768 (iii) 923,452,001,234 (iv) 1,234,322,566,677
Respondent:	Difficult to mention them, but let me try; (i) Mpen du, ɔha ne Aduasa-miƐnsa (ii) ɔpe aduonu-nan, mpem Ahanum ne du, ahanson aduosia-nnwotwe (iii) ɔpepe ahankron aduonu-mmiensa, ɔpe ahanan aduonum mmienu, akyiripo apem, ne ahaanu aduasa-nnan. (iv) ɔpepepe baako, ɔpepe ahaanu aduasa-nan, ɔpe ahaasa aduanun mmienu, mpem ahanum aduosia nsia, aha-nsia aduoson-nsoo.
Researcher:	Wow! You are good at Akan number recognition.

Note:

The responses given by the interviewee was splendidly given out. Several opinions were sought by ten (10) interviewees who gave equally good response for their knowledge on Akan numeration concepts. Few interviewees flopped in their knowledge of numeration recognition in the Akan perspective. Others also mixed their responses in Akan ethnomathematics on numeration with the formal one. Quite a lot of Akans misunderstood the recognition of the term *ɔpe* to denote a million. They were misusing this number concept from informal numeration. In the Akan numeration, the *ɔpe* stand for the uniqueness of a million representation. Some respondents misuse it and say *ɔpepepeepee* to in billion connotations. Every *ɔpe* stand for million, the next *ɔpe (ɔpe-pe)* extend to billion, the next *ɔpe* (*ɔpe-pe-pe*) further extend to trillion and so forth

The results show a number place value pattern that is quite similar to what the formal systems suggest. We organize responses of few numerations‟ samples for the few students‟‟ opinions on their knowledge on Akan ethnomathematics in Table 4.14. A comparison of response for Akan numeration concept is compared with the numeration of the formal way of mentioning the Hindu-Arabic numerals.

Table 4.14: Comparison of formal and informal numeral identification

Hindu-Arabic Numerals	Formal numeration	Informal Akan numeration
678	Six Hundred and seventy-eight	Ahansia aduoso nnwotwe
10,133	Ten thousand, on hundred and thirty-three	Mpen du, ɔha ne Aduasa-miƐnsa
101,123	One hundred and one thousand, one hundred and twenty-three	Mpem ɔha ne baako, ɔha ne aduonu mmiensa
1,234,567	One million, two hundred and thirty-four thousand, five hundred and sixty seven	ɔpe baako, mpem ahaanu ne aduasa anan, ahanum aduosia nson
24,510,768	Twenty four million, five hundred and ten thousand, seven hundred and sixty eight	ɔpe aduonu-nan, mpem Ahanum ne du, ahanson aduosia-nnwotwe
102,567,113	One hundred and two million, five hundred and sixty seven thousand, one hundred and thirteen	ɔpe ɔha baako ne mmienu, mpem ahanum aduosia nson, ɔha baako ne dummiensa
1,045,000,208	One billion, forty five million, and two hundred and eight	ɔpepe baako, ɔpe aduanan nnum, (akiripo) ahaanu ne nnwotwe
10, 001,001,001	Ten billion, one million, one thousand and one	ɔpepe du, ɔpe baako, apem baaako ne baako
923,452,001,234	Nine hundred and twenty three billion, four hundred and fifty two million, one thousand, two hundred and thirty four	ɔpepe ahankron aduonu-mmiensa, ɔpe ahanan aduonum mmienu, akyiripo apem, ne ahaanu aduasa-nnan
1,234,322,566,677	One trillion, two hundred and thirty four billion, three hundred and twenty two million, five hundred and sixty six thousand, six hundred and seventy seven	ɔpepepe baako, ɔpepe ahaanu aduasa-nan, ɔpe ahaasa aduanun mmienu, mpem ahanum aduosia nsia, aha-nsia aduoson-nsoo
23, 456, 789,012,345	Twenty three trillion, four hundred and Fifty six billion, seven hundred and eighty nine million, twelve thousand, three hundred and forty-five	ɔpepepe aduonu-mmiensa, ɔpepe ahanan aduonum nsia, ɔpe ahanso aduowotwe nkron, ne mpem dumienu, ahaasa aduanan-num
1,234, 567, 890,112,345	One quadrillion, two hundred and thirty four trillion, five hundred and sixty seven billion, eight hundred and ninety million, one hundred and twelve thousand, three hundred and forty five.	ɔpepepepe baako, ɔpepepe ahaanu aduasa nnan, ɔpepe ahanum aduosia nson, ɔpe aha-nnwotwe aduokron, mpem ɔha baako ne dumienu, (akyiripɔ) ahaasa aduonu nnum.

It is noted that the generic numerical representation of Akan numeration concept from informal (oral) presentations in any number stated in the Hindu-Arabic numerals could be represented equally in Akan language-based ethnomathematics. The numeration stated in any form was dictated by the cultural reformation of the ethnic group of people who needed arithmetic education (Mosimege, 2017; Muzdalipah & Yulianto, 2018).

The Akan ethnomathematics is richer in various number generic representations just like the formal representation suggested by the curriculum, (MOE, 2020). It can however be used to support the teaching of various number and numeration concepts to students in the curriculum implementation process. The study saw from the field survey of Akan numeration ethnomathematics as a linkage to the teaching of real number systems (most especially on rational number concepts), sequence and series, binary operations and number bases. For example, the Akan informal oral numeration systems suggest to some extent, an arithmetic sequence. An arithmetic sequence is a sequence of numbers such that the difference of any two successive members of the sequence is a constant. An example is the natural counting numbers;

1,	2,	3,	4,	5,	6,	7,	8,	9,	10,	…
Baako	mmienu	mmiensa	anan	enum	nsia	nson	nnwotwe	nkron	edu	

A limitation to Akan ethnomathematics is the inability to express number and numerations in formal symbol terms and structures. The number systems is read orally and transmitted in oral tradition forms. Should there have been identified a more formal illustration to represent them with symbols, a proper formalization of the mathematics would have been realized. Teachers could use the Akan numeration concept to create some linkage to the formal one for selected mathematical content taught. For example, we can associate this Akan ethnomath to test student knowledge on set.

4.3.2 Akan Ethnomathematics on Measurement of length and distance

The Akan people have peculiar means of recognizing arbitral measurement of length and distances for small, medium and large dimensions. In the formal system, the SI unit is deemed appropriate for the formal classroom curriculum implementation.

Area and relationships among area units is another mathematical practice observed in the agricultural setting of most Akan communities with regard to conversion, comparison and arbitral measurement of length and area. Table 4.15 below shows how the Akans demonstrate arbitrarily measurement of length with western unit interconnections

Table 4.15. Interconnection between Akan indigenous units of length with western formal description.

Local unit of length	Description	Estimation in Western unit
Nsatea	The thickness of one middle finger	1 finger 2.5 cm
Nsayam	Distance from the tip of thumb to the tip of middle finger	1 finger span 25cm
Basafa	Distance from elbow to the tip of middle finger	1 hand 25cm
Abasa	Distance from shoulder to the tip of a middle figure	1 hand 50cm
Anamon	One step or stride	1 stride 1 m
nsatremu	*Hug –distance from the tip of middle finger in the left hand to the tip of middle finger in the right* hand (when stretched)	1 hug 2m
kwansin	Kilometre	1 km
Kwantenten	hectare	1 hectare

Table 4.15 presents indigenous units of area in Akan people. As Table 4.15 presents, people of Akans use different indigenous units for area measurement in agricultural setting. In this regard, the study investigated that *nsatea* (the thickness of the middle figure) denotes one figure length of about 2.5cm. Similarly, greater dimensions of length measured in kilometres and hectares are seen as *kwansin* and *kwantenten*

4.3.3 Set ethnomathematics Illustrations

Akan people recognise their knowledge in set. The concept of sets is referred to as *akuokuo or aboaboa or mmoanoo.* Figure 4.17 below shows set recognition from market scenes where things are organised for sales in their unique likeness, grouping forms and sales mapping in their various forms.

Figure 4.17: Akan market scene with set concept ethnomathematics

Akans recognise set as the mathematical application to the collection of different things organised in a common likeness as seen from Figure 4.17. The grouping of objects for sales contains elements or members such as vegetables (onions, green papers, tomatoes and among others), various forms of fishes, foodstuffs (cassava, cocoyam, plantain and among others). The association of this concepts can be the grouping of mathematical objects of any kind such as numbers, symbols, points in space, lines, other geometrical shapes, variables or even other objects listed in their similarities and likeness.

Table 4.16 shows set recognition from formal listing and informal listing form organised by students in class activities by recognising set statement, set listing and set builder notation forms respectively.

Table 4.16: Ethnomathematics illustrations on set concepts to connect formal listing

Set Concepts in statement form	Formal Listing	Informal Akan set listing
A={set of even numbers less than ten}	A={2, 4, 6, 8}	A={mmienu, anan, nsia, nnwotwe}
B={Set of prime no. between 10 to 20}	B={11, 13, 17, 19}	B={du-biako, du-mmiensa, du-nson, du-nkron}
C={Set of odd numbers less than ten}	C={1, 3, 5, 7, 9}	C={baako, mmiensa, ennum, nson, nkron}
D={set of 3 common vegetables}	D={tomatoes, garden eggs, pepper}	D={ntoosi, ntorowa, amako}
E={set of four fruits in sold in the market}	E{pear, mangoes, orange, pineapple}	E={paya, mango, ankaa, aborobe}
F={set of four things found in the kitchen}	F={earth-bowls, ladle, coal-pot, blender}	F={apotoyowa, tankora, mukyia, tapoli}

The concept of sets is referred to as *akuokuo or aboaboa or mmoanoo* as seen from Table 4.16 and Figure 4.16 respectively. It is their belief that, things could be grouped into groups and groupings based on similarities implied by the objects. This application is seen typically in Akan communities in market transactions where items for sales are grouped into similar items showing set representations. Students were drilled to list set definitions using Akan numeration concepts as illustrated in Table 4.16.

4.3.4 Some Akan ethnomathematics activities supporting the teaching of Algebra

Teaching about algebra is quite abstract since various unknown parameters are considered. Akan people have peculiar means of communicating abstractness through tales, riddles and puzzles as a recreational ethnomathematics. Tales has long been seen as one entertaining part of human endeavour. One part of Akan ethnomathematics dynamics is the use of folklores, folktales, riddles and puzzles and naming techniques to drill the youth about their content knowledge of their world.

Table 4.17 below shows how Akan ethnomathematics recognises the concept of algebra abstraction. Students made connections to link the formal way of connoting an unknown variable to abstractness.

Table 4.17. Depiction of indigenous Akan discourse connotation for algebra concepts

Ethnomath connotation	Description	Formal representation
Biribi	Something (a variable x)	x
Nkyemu/Ha-mu-nkyemu (Ebi)	Some [percentage (%) of x]	$x\%$
Nohwoaa/awie3	infinity	∞
Ɛfa bi (nkyemu-mmienu)	half (of x)	½ x
nyinaa	all	100% of x
Ahodo)	*Different replications*	x.y
akyiri	limits	$\lim_{x\to\infty} x$
Ntifirimu	Difference (of numbers)	$x - y$
Nkabom	Sum (of numbers)	$x + y$
Nkyemu/nkyekyemu	Division (of numbers)	$\frac{x}{y}$
Mmohoo-mmohoo	Multiplication (of numbers x, and y)	$x \times y$

The Akan ethnomathematics of algebra concepts is also orally expressed to connote their mathematical discourse as seen from Table 4.17 The concept of a variable x means *biribi.* Percentage of x is expressed as *ebi* *(x%).* The concept of *all* also represent *100%.* The concept of limits *and infinity* is seen as *akyirikyiri nohoaa.* Akan use the discourse *nkabom*, *ntefirimu, mmohoo-mmohoo, and nkyekyemu* to show the sum (+), difference (-), multiplication (×) and division of numbers in terms of x and y respectively.

The conceptual meaning that initiated a naturalistic view of mathematics regarding ethnomathematics is perceived well by D"Ambrosio, (2006) as a research program in the history of and philosophy of mathematics with pedagogical implications. The focus of it, according to D"Ambrosio (2001) is to focus on the art and techniques of using cultural principles to cope with mathematics teaching. The area of focus under this regard is to bring the essence of creativity, citizenship, exploration and pedagogical strand that would enhance teaching and learning of mathematics. Today"s mathematics educators have lost the sight of being innovative and still admits to the old intransitive approach of materialising mathematical content and problem strategization. For example, you would sample textbooks from a community in Bolga or Yendi or any of the northern tribe of Ghana only to see and read about words problem in mathematical topics where strange Akan names or perhaps western names are used to exemplify the word problems.

Activity 3*: *Students were asked to analyses the following word problems.

1. ***Mensa*** and ***Anane*** shared 20 ***cedis*** in the ratio of 2:3 respectively, how many would each get?
2. Amina and Abu shared Timpani in the ratio of 2:3 respectively. How many would each get?
3. D"Ambrosio went to a supermarket to buy Pizza, suppergety, and cheese at the cost of $40. If the price index for pizza is twice that of Suppergety and the price of a pack of cheese is $2 more than suppergety, how much is the cost of each food item purchased?

Students were asked to analyse the word problems from the activity 3. This was to investigate their difficulty level and examine what coursed their difficulty. Students attributed the difficulty associated with the problem investigation to hostile choice of word especially from activity 3 with respect to unfamiliarity to names "D"Ambrosio" food items such as "pizza" and currency realism such as „"dollar ($)"". To them, the realistic mathematics education is violated here.

The semantic connotation of each mathematical problem can confuse the most ordinary learner. The context by which the questions are specified can be unfamiliar to the mathematics problem solver. Problem one and two are best understood by learners within Akan and Bolga communities respectively who are familiar with culturally-based names like Kofi and Ama, Amina and Abu as well as their popular Cedi currency. In the same way, when students were given mathematics problem three, the majority of the students got confused because of the diction and Eurocentric semantic connotations. An unfamiliar name D"Ambrosio or perhaps unfamiliar delicacy Pizza, suppergetty and cheese as well as unfamiliar currency not so much adapted to their

African Ghanaian environment nor culture might drag their understanding down. This hinder their understanding level of the question. Using most familiar names from their land of birth; the culture they know, will help facilitate the level of understanding.

Majority of Ghanaian core mathematics books surveyed from across the regions use most popular books deem appropriate to help them pass West African Secondary Certificate Examination (WASCE). On the contrary, the ideal ethnomathematics application is lagging. A survey in the Core mathematics teaching syllabus, MOE (2010) has this mathematical problem as an activity:

1. TLA: Guide students to construct a formula for a given mathematical task. E.g. Aku has *y* cedis more than Baku, if Baku has *x* cedis, then Aku has (x + y) cedis [adapted from MOE (2010) core mathematics syllabus page 15]
2. Construct a formula for a given mathematical task, E.g. Aku has y mangoes more than Baku. If Baku has x mangoes, how many do they have altogether? [MOE, (2010) syllabus page 15]

Teaching mathematics with RME in which the adaptive native names of the people are used to exemplify the mathematics, allow students to focus and understand the word problems well, (Herawaty, Widada, & Novita, 2018; Ilyyana & Rochmad, 2018; Nursyahidah & Saputro, 2018; Widada, Herawaty, & Anggoro, 2019; Yosopranata, & Zaenuri, 2018).The multicultural system within the Ghanaian settings must be adhered to in order to bridge the gap and help both teachers and learners adjust to meaningful teaching and learning of the mathematical content.

4.3.5 Geometric-Based Game Illustrations:

Culture and Geometry are interconnected, making school geometry closely related to the environment as well as the culture in which the mathematical concept is taught. In the teaching of mensuration for example, ethnomathematics could be used to exemplify various applications of ethnomathematics ideas adapted to suit the child‟s environment. A lot has been researched on ethnomathematics as basically concerning geometry and mensuration. We can establish ethnomathematics geometrical as a linkage to Formal mathematical concepts using existing artefacts

Some Akan ethnomathematics games illustrate their knowledge in geometry and mensuration. The *Peele game* (sometimes called *kantalae* deduced from probably contour line and other different names) is played based on the knowledge and application of Akan concept of geometry. The game is drawn on the ground with traces of geometrical shapes such as squares, rectangles with an ending circle. Recognition is given to stepping on line segment of the geometrical shape as bases of losing to an opponent. The Figure below (Figure 4.18) is the layout of the Akan *peele* game performed by both male and female children.

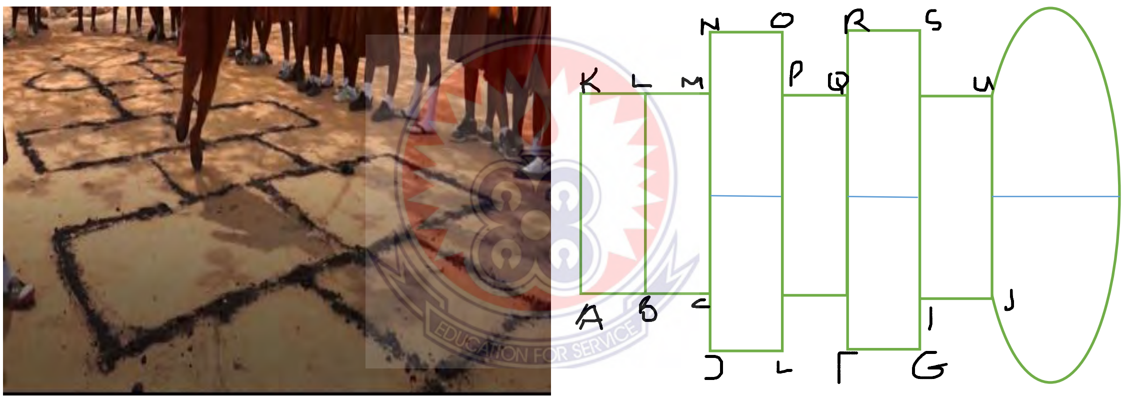


Fig4.18: The Akan Peele Game showing geometric knowledge and applications

The game as seen from Figure 4.18 is played with forward and backward movements by limping through the various geometrical plane shapes. Stepping on the line segments denounces a foul played which gives the other opponent the chance to step in and play equally. Able to go through the spaces of the geometrical shapes allow a victory, and the reward is to turn back and flip the marble back to create ownership of one of the faces of the plane geometrical shape as the person‟s *plot.* No player has the right to step in that plot except himself or herself. The game could be played by mixed gender.

Student drew the outline of the game on paper and labelled the joints A, B, C, …, U as seen from Figure 4.18. They found the total surface area and perimeter of the layout of the *peele* game.

4.3.6 Ethnomathematics on Earth bowl wares (artefact-based thnomathematics)

Figure 19 displays traditional indigenous artefacts from the selected part of Akan communities. These are typical ethnomathematics which speaks implication of both informal and formal mathematical concepts regarding conics (circles, parabola. Hyperbola, cylinders and cones). Figure 4.19 shows some selected kitchen artefacts suggesting ethnomathematics of mensuration as the content scope of the SHS core mathematics.

Figure 4.19: Akan concept of mensuration and conics embedded in earth bowl artefacts

Various traditional Ghanaian kitchen utensils has circular artefact of which most Ghanaian children are exposed to before going to school (see Fgure 4.19). The

Ghanaian multicultural system is gifted with a lot of traditional indigenous artefacts, traditionally engineered to form an informal technology that has connection to mathematical constructs that come in the form of geometry, conics, mensuration, and geometrical shapes such as triangles, squares, rectangle, rhombus, and kite and among others.

4.3.7 Akan concept of pi (π) and its ethno-technology application

The mathematical concept of mensuration is seen as some of the artefacts are engineered as circular based. For example, circles, cones, cylinders, parabolas, ellipse, hyperbolas are seen from the various kitchen technological tools used for grinding, storing food and water, eating earthen bowls and among others. Most Akan techno-ethnomathematics base is connected to their artefacts and production of things. The Figure 4.19 below, for example, is manufactured based on the manufacturer‟s knowledge of circles (mensuration). The researcher was interested in finding out the manufacturers‟ knowledge in circle characteristics and asked students to investigate the pi as seen from Figure 4.20 below.

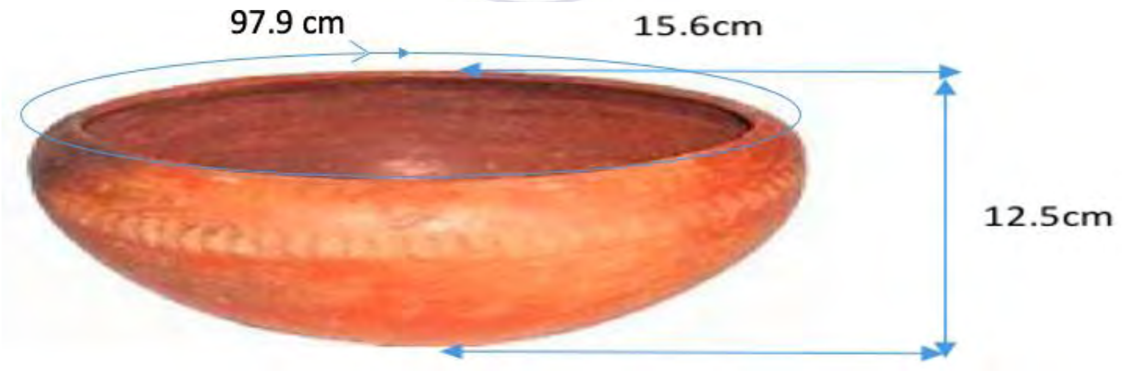


Figure 4.20: Asanka concept of pi

When the radius, height and circumference was measured from Figure 4.19, the estimated pi, circumference and diameter were observed as:

$$diameter\ (d) = r + r = 2r$$

$$pi\ (\pi) = \frac{circumference}{diameter} = \frac{C}{d}$$

Making circumference a subject of equations becomes

$$C = \pi d = \pi(2r)$$

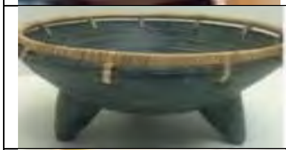
$$C = 2\pi r$$

where the radius of the circular *asanka* displayed in Figure 4.19. Students were put into groups with these selected artefacts and measured the circumference and diameters. They threaded around the circumference of the *asanka* with a rope. They then stretched the measured length on a rule to observe the circumference as 48.9. Similarly, they measured the diameter of the *asanka* to observe the length when stretched on the rule as 12.5cm. To find the pi, they took the ratio of C:d as

$$pi\ (\pi) = \frac{circumference}{diameter} = \frac{C}{d} = \frac{48.9}{15.6} \approx 3.14$$

Hence the estimated pi of $\pi = 3.14$ depicts precision in the craftiness of the circular artefact to conform to the formal concept of $pi\ (\pi)$. Table 4.18 below illustrate selected artefacts from Akan indigenous technology that were tested to check whether concept of pi exist.

Table 4.18: Selected Akan circular artefact with concept of pi (π)

Circular Artefact	Name	Circumference (C)cm	Diameter (d)	$\left(\frac{C}{d}\right)cm$
	Apotoyowa	28.1	8.9	3.157
	Ahina	11.8	3.8	3.145
	yaawa	24.4	7.8	3.142
	Asanka	22.8	7.3	3.144
	tapoli	12.5	3.8	3.289
	Suhina	34.6	11.1	3.121
	Waduro	32.4	10.3	3.145

The study investigated further to find out whether some selected Akan indigenous circular artefacts were crafted with formal concepts of circle (technocracy). Table 4.18 summarised students answers to pi values estimated from selected Akan circular-based ethnomathematics. What characterizes the regularity of circle is the concept of $pi(\pi)$ which is approximately considered as 3.142 (3 d.p.). A marginal error of approximating to pi value as 3.1 decimal place suggest a clearer picture of pi application and knowledge from informal ethnomathematics. Akan people who make and sell them has on the average, the concept of pi approximately 3.14. The knowledge used in creating, crafting and engineering them shows a significant informal mathematics. Children daily use of them in their homes help them to some extent, and build their sensory stimulus to revive their relevant previous knowledge to the mensuration concept from the formal curriculum implementation. Creating awareness of ethnomathematics in the curriculum implementation process is what ethnomathematicians challenge mathematics educators to consider in their pedagogical actions (Peni, 2019)

The study investigated geometrical linkage to formal mathematical concepts from this Akan ethnomathematics based on artefacts. Table 4.19 shows the interconnection of these ethnomathematical constructions closely linked to mathematical content suggested by the mathematics curriculum. Participants were asked to identify as many as geometrical shapes seen from this ethnomathematics edifices from their neighbourhoods. The possible response was jotted down with their reasons.

Table 4.19: Respondents view on their knowledge of geometrical shapes to identified artifacts from their community.

QUESTION ITEM	ANSWER/RESPONSE	REASON FOR RESPONSE
	1. Cone 2. Cylinders 3. Rectangle 4. Circles	The Figures have circles with conical walls and rectangular or trapezium entrances in an irregular form
 (UNESCO, 2008)	1. Rectangle 2. Triangle 3. Square	Building walls are rectangular in shape. Roofing edges are triangular in shapes
	1. Circles 2. Cones 3. Cylinder 4. Ovals	Earth-bowls are circular in nature. *Tapoli* (blender) are truncated cones. *Yaawa* (jars) are spherical

Participants were able to link their formal mathematics knowledge on geometry to the problem given in Table 4.19 where they were given the problem of identifying the appropriate geometrical shape that is associated with the identified artefacts from their community. Majority of those who have had a formal education up to grade 6 (primary 6) were able to associate the geometrical shapes to the artefacts as circles, rectangles, squares, rhombus, spheres, cones, cylinders, cones, kites and cuboids.

In the bid to establish the importance of ethnomathematics artefacts, in illustrating meaning to early grade mathematical concepts (Baccaglini-Frank, 2015), we turn our attention to the critical role of the structure of artefacts and the ways that young students interpret and construct representations. Secondary school students were tested whether their recognition to daily exposure to such artefacts would help them solve mathematics problem associated with merging the formal and informal. Students were given the following problem from Figure 4.20.

Given the diagram in the following specimen A-D. if the rectangle in specimen A has length (l)=15cm, width (b)=10cm and the height of cylinder is 5cm with radius 8cm whiles the conical roof in specimen C has radius 12cm with height 2.5cm respectively. Find the total surface area of the building in spacemen D made out from A, B and C.

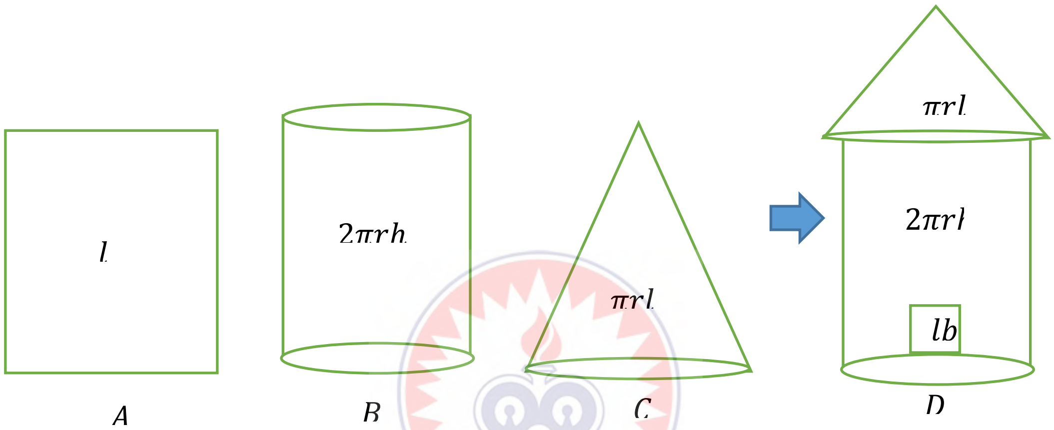
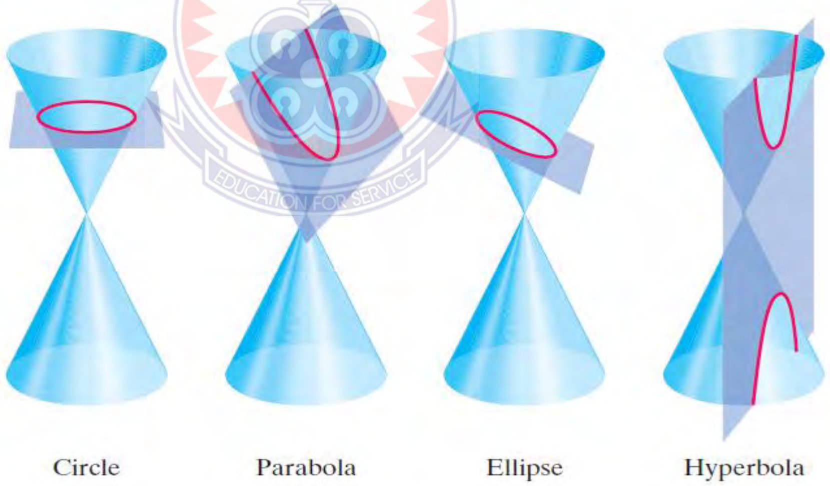


Figure 4.20: Problem spacimen connecting Akan informal ethnomath to the formal school mathematics.

Few of the students were able to figure out some routine and non-routine attacking phase to the problem. When they were however given the clue of the visualization process, they were able to internalize the mathematical representation to unlock the solution. Students begin to internalise the visualised „structure" of the diagram associated with the artefacts, and it could be inferred that they have internalised the structure of the grid. The use of structure sense is embedded within this example as seen from Figure 4.20. The ability to decompose or partition mathematical representations is directly linked to the child"s strategies for calculating it. This is most often articulated by the child"s strong visual imagery of buildings to be broken up and through verbalisation of „*I break… into parts*",„*components are put together*" and among others. The key process here is not counting by ones, computing all at the same time or repeated addition of the combined concepts by structuring and partitioning or „*breaking up*" into constituent part and solving to integrate them together.

Knowledge of circular artefacts discussed so far suggest to the most formal way, the concept of conics become meaningful. There are embedded concepts of circles, parabola, ellipse and hyperbola in the various illustrations of Akan ethnomathematics, (see Figure 4.21). Researchers are of the view that, as we create linkage by bridging the gap between ethnomathematics from informal position to formal mathematical learning concept, the application of mathematics becomes more meaningful, interesting and appreciative.



Source: Adapted from Stitz C. & Zeager J. (2010).

Figure 4.21: Interconnection between conic section Akan circular ethnomath

From Figure 4.21, an assembly of conic section comprising of circles, parabola, ellipse, hyperbola and other geometrical course description is suggesting a close connection to

Ghanaian traditional ethnomathematical technologies that could serve as a base of curriculum implementation on the teaching of geometry and mensuration part of the formal scope of the mathematics teaching in Senior High Schools.

4.3.8 The concept of Perimeter and area measurement

Other forms of body gestures that also comes in the form of sensorimotor, perceptive and kinaesthetic-tactile experiences is the steps and hand-counting techniques popularly seen among the Akan ethnomathematics. Other arbitrary measurement activities such as fathom(s) are used to establish measurement of perimeters. These fundamental body movements of ethnomathematics are used for the formation of mathematical concepts. The key role attributed to the use of hand-stretched counting and footing in the development of number sense also seems to be highly resonant with the frame of *embodied cognition*. Step counting (footing) and hand counting has long been used as a method of measuring distance. Starting in the mid-1900s, researchers became interested in using steps per day to quantify physical activity that needs measurement of length and tracing angles. Steps counting have several advantages as a metric for assessing physical activity: they are intuitive, easy to measure, objective, and they represent a fundamental unit of human arbitrary counting activity. However, they can be used as arbitral measurement tools when scientific tools are absent to facilitate teaching and learning (Cycleback, 2014; Davids, 2016).

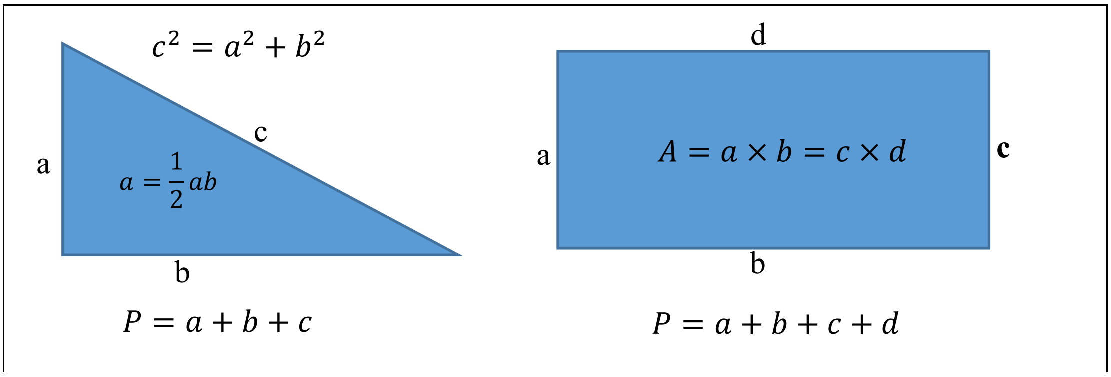
Figure 4.22 below is an exhibition of how students use Akan ethnomath measurement methods to estimate the parameter and area of marker board and classroom.

Fig 4.22: Foot and Hand counting system of measurement.

The Akan people flip their hands along the line segment in which the measurement is taking. An arbitral counting of the distance is recorded and comparison made to other distances. Terms used to connote distance measurement are *anamɔn, kwansin, kwansitenten, basafa, kwantia,* etc. In the same way, some (for example, the farmers and surveyors) stretch their foots to count for shorter distance and stretches the long leg for counting length of longer distances such as plot of land. Participating students were guided to use practical activities of foot and hand counting techniques to measure distances for parameters and geometrical measurement during mensuration lessons. Such ethnomathematics activities were used to establish meaning to perimeter of rectangles, squares and recognition of Pythagorean theory;

$$c^2 = a^2 + b^2$$

As seen from box 5 below. The area and perimeter of the triangular and rectangular plots were found using the foot-step and hand arbitral counting system of Akan ethnomathematics demonstrated in Figure 4.23 above



Box 5: Estimating perimeter and area measurement using foot and hand counting.

The key content and mathematical concept or construct the ethnomathematics illustrates was to recognize the Pythagoras theorem based on Pythagorean principles to establish the area of the fields as well as the perimeter enclosed in the given plot. The mathematical processes associated with these ethnomathematics measurement suggests a metacognition of Akan concept of geometry illustrated through body movements and gestures, games, artefacts and indigenous technology such as buildings, roofing, etc. Table 4.20 below illustrate some Akan fractional terms compared with school formal mathematical descriptions.

Table 4.20. Some Fractional terms in Akan Culture

Fractional term	Description in English	Mathematical symbol
Efa	Half of an object	½
Nkyemu-Nnan	Quarter of an object	¼
Nkyemu-Nwotwe	One eighth of an object	1/8
Nkyemu Dunsia	One sixteenth of an object	1/16
Efa ne nkyemu-nnan	Half and quarter (½ + ¼ = ¾)	¾
Nkyemu nnan ne nkyemu nnwotwe	Quarter and one eighth (¼ + 1/8 = 3/8)	3/8
Nkyemu-Nnwotwe ne nkyemu dunsia	One eighth and one sixteenth (1/8 + 1/16 = 3/16)	3/16
Ohafa	Fifty percent (50/100)	50/100
Ohamu-nkyemu	Percentage	100%

Concept of Similarity and Congruence:

Through the observation, researcher found that almost all Akan community artefacts used the concept of similarity they called *asesɛsɛm* or sameness. Congruence refers to similarities and resemblance between two or more items, figures and materials being observed. They can be different congruent materials existing among the geometrical shapes surveyed from observations in the Akan communities and comments from the focus group who mostly create the artefacts. Figure 4.25 below shows Akan ethnomath on the concept of congruence from *mukyia*.

Figure 4.25: The mukyia with concepts of congruence and similarities

The *mukyia* from Figure 4.25 is found in almost every traditional home of most villages within Akan communities. Apart from the modern usage of gas cylinders and coal pots, the traditional way the Akan people cook was to mount heaps of earth-mud, sand etc. to form some stands by which cooking pot could be placed on for fire heating and cooking. For the *mukyia* to hold the pot well, it needs to match well with concept of congruence and similarity.

4.3.10 Some Akan ethnomathematics activities supporting the teaching of Data.

Akan games have been explored by some Ghanaian authors with implicit ethnomathematics implications (Davis, 2016; Nabie et al., 2018; Rattray, 1930). Among these formal mathematical concepts, game-based ethnomathematical moves done by children and adopted from the cultural perspective to support understanding of what we teach. These may include finger counting, traditional counting system, debt tallying, counting based games such as Oware, ludo etc. Among the Akan communities are tallying concepts to map up data entry of debts called *sandanho* (as already discussed under tallying for debt)

Activity/experimental example: Student participants were guided to drill the play of their lucks in rolling the ludo die once. Table 4.21 shows how students represented the information in frequency distribution Table 4.21 through stroke tallying of rolling die experiment and graphical representation.

Table 4.21: Frequency distribution from Ludo die rolling.

Die Face (x)	*Stroke Tally*	*Frequency* (f)	fx	fx^2	*Cum frequency*
1	~~||||~~	5	5	5	5
2	~~||||~~ |||	8	16	32	13
3	~~||||~~ |	6	18	54	19
4	~~||||~~ ~~||||~~ ||	12	48	192	31
5	~~||||~~ ~~||||~~	10	50	250	41
6	~~||||~~ ||	7	42	252	48
TOTALS		**48**	**179**	**785**	

From the frequency distribution Table 4.21, the modal throw of the die face was revealed by students as face 4 since it carries the highest frequency. Students were guided through various statistical concepts such as measurement of central tendencies (mean, median and mode). The variability measure of the distribution was also computed. The measurement of central tendencies and spread were computed by students to serve as data analyses.

The Ludo game has probability and statistical concepts best illustrated by ethnomathematical concepts from informal position as well as formal mathematical concepts in statistics and probability and general number concepts. This is consistent with some African ethnomathematicians who suggest to mathematics teachers of the need to integrate school mathematics teaching with games (Mereky & Mereku, 2013; Nabie, 2015)

4.4 Research Question 3:

Is there any effect of ethnomathematics integration to teaching formal school mathematics on students' achievement in studying mathematical concepts?

Performance of students is influenced by so many factors best perceived by researchers, stakeholders of education as well as students and teacher related factors. This section discusses the effect of ethnomathematics approach to teaching mathematics on students" academic achievement. Assessment in mathematics places an evaluation of the extent to which mathematics achievement is measured and evaluated. This serves as the bases of evaluation and placing judgement about the learning outcome influenced by the pedagogical actions used as the bases of instruction. Analyses is based on collected data on students" academic achievement (scores obtained from the ethnomathematical lessons). The analyses is based on descriptive and inferential statistics to determine the extent to which ethnomathematics approach to teaching school mathematics affect students" understanding and learning progress.

After exploring the Akan ethnomathematics dynamics from the informal position, a further investigation into its effect on the teaching and learning was investigated. A demonstrational lesson through quasi-experiments was carried out in a selected school from the Akan community at Techiman Senior High School. Students were given series of teaching for selected concepts from the Ghanaian core mathematics. Teaching was done under ethnomathematics pedagogical actions as suggested by (Forbes, 2018) ethnomathematics handbook. However, the classroom interaction considered the formal and informal position of teaching and learning mathematics and ethnomathematical concepts in the curriculum implementation process. The conceptual framework adapted from ethnomathematical framework in which the informal and formal mathematics are considered in the concept teaching of mathematics (Peni, 2019).

This section considers descriptive and inferential analyses to test the null and alternative hypothesis that:

H_0: There exist a significant effect of ethnomathematics approach to teaching

formal school mathematics on students" achievement in studying selected concepts in Ghanaian core mathematics curriculum.

H_1: There does not exist a significant effect of ethnomathematics approach to teaching formal school mathematics on students" achievement in studying selected concepts in Ghanaian core mathematics curriculum

At a significant test of $\alpha = 0.05$, the study inferential statistics considered the studentized t-distribution, the z-test statistics and the analyses of variance assumptions as and where necessary and appropriate.

4.4.1 Analysis of Performance of the Students Taught with Ethnomathematics Teaching Approach

The Table 4.22 gives the observed scores of students" pre-test for the selected class taught. Analyses of the nature of students" scores before the ethnomathematics application and demonstration lessons are given in this section. Table 4.22 below gives a descriptive analysis of students observed scores in the respective classes.

Table 4.22: Descriptive statistics of students observed scores for pre-test

	N	Minimum	Maximum	Mean		Std. Deviation	Skewness	
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Std. Error
Arts A Class Pre-test scores	38	18	74	46.94	2.297	15.064	.131	.361
Arts B Class Pre-test scores	48	25	61	42.58	1.070	7.014	.188	.361
Valid N (listwise)	86							

Source: Fieldwork, 2020

Table 4.22 gives descriptive statistics of students observed scores in pre-test. Classes A and B constituted the experimental class. The pre-interventive score before ethnomathematics lesson was recorded for each respective class. Each class constituted 38 and 48 participants respectively. Class A minimum score was 18 with a maximum score of 74. Class B had a minimum score of 25 and a maximum score of 61. The respective means for the two classes were 46.94 and 42.58 with standard deviations 15.064 and 7.014. Class B ability level seems to have more closed variability than class A. The standard error however seems to show similar reliability evidence.

The boxplot in Figure 4.26 shows the weighted means for each chosen class.

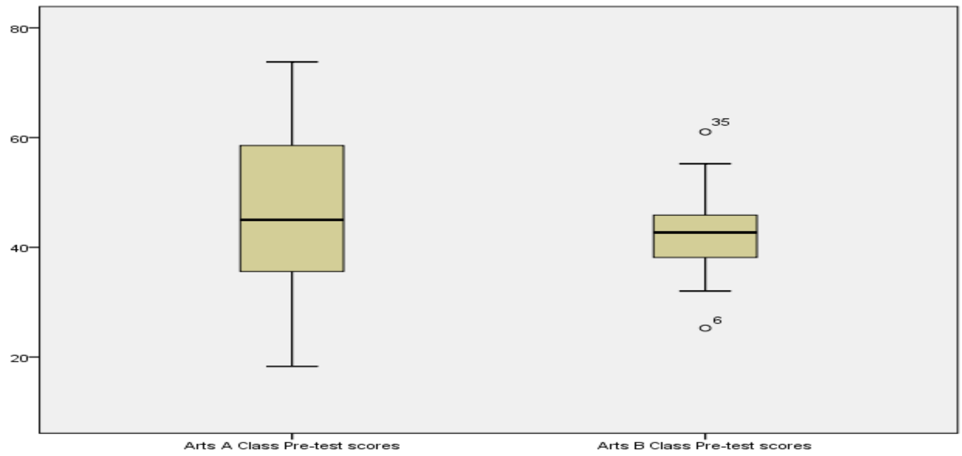


Figure 4.26: Box plot of students obtained scores in Pre-test

Boxplot in Figure 4. 26 splits statistical data of students observed pretest into quartile groups. It rated spread in the distribution and established the central tendency trend of the distribution being compared in classes A and B scores respectively. From the boxplot in Figure 4.26, Arts A class has greater spread than Arts B class. Similarly, the means of class A is quite similar to the that of class B as depicted by the whiskers of the graph. Figure 4.27 gives normality assumption of the distributed pre-test scores.

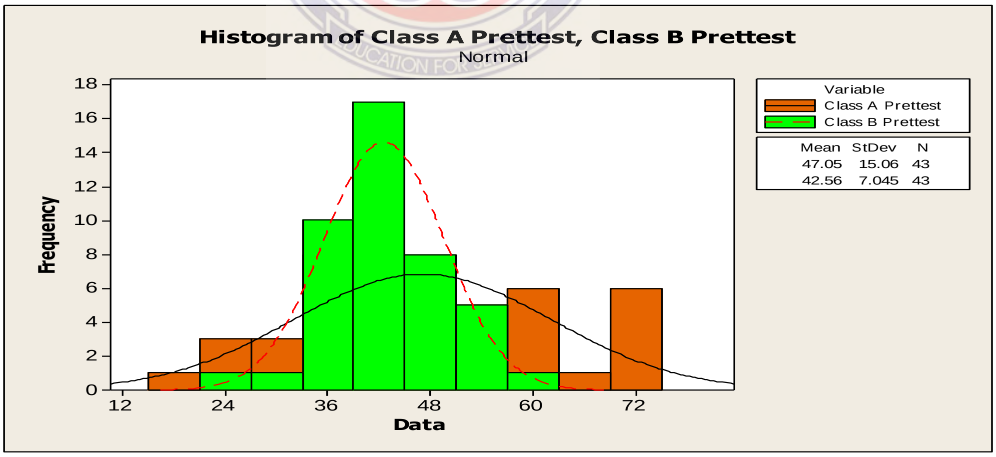


Figure 4.27: Normality assumption of students obtained scores in Pre-test

Figure 4.27 also explains the normality assumptions associated with the pre-test scores. From Figure 4.27, the normality assumption associated with the Arts A and B classes pre-test is specified with super-imposed skewness and kurtosis. Art B class has closed variation compared to Class B in the pre-test scores with mean and standard deviations (42.56, 7.045) compared to Art A class (47.05, 15.06) respectively.

The study considered the nature of the post-interventive scores (post-test) after the ethnomathematics lessons in Table 4.23.

Table 4.23: Post-Test scores Analyses

	N	Minimum	Maximum	Mean		Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Std. Error	Statistic	Std. Error
Arts A Class Post-test Scores	38	47	84	68.58	1.245	8.163	-.300	.361	.175	.709
Arts B Class Post-test Scores	48	35	89	63.90	2.015	13.214	-.187	.301	-.644	.709
Valid N (listwise)	86									

Source: fieldwork 2020

Table 4.23 and Figure 4.23 also gives descriptive statistics of students observed scores in post-test. The post-interventive test scores of the students were recorded after the experimental lesson. Classes A and B constituted the experimental class. The pre-interventive score after ethnomathematics lesson was recorded for each respective class. Each class constituted 38 and 48 participants respectively. No student dropped out. Class A minimum score moved from 18 in the pretest score to 47 in the post test score with a maximum score of 84. Class B had a minimum score moved from 25 in the pre-test to 35 in the post-test with a maximum score of 89 compared to 61 in pre-test score. The respective post-interventive means score for the two classes were 68.58 and 63.90 with standard deviations 8.163 and 13.24. This time, class A ability level seems to have more closed variability than class B. The standard error however seems to show similar reliability. The distribution has negative skewness for both classes‟ scores showing good performance. That is majority of the students scored above the mean score of 68.58 and 63.9 respectively.

Figure 4.28 compares the performance of students in pretest and post-test scores using trend graph.

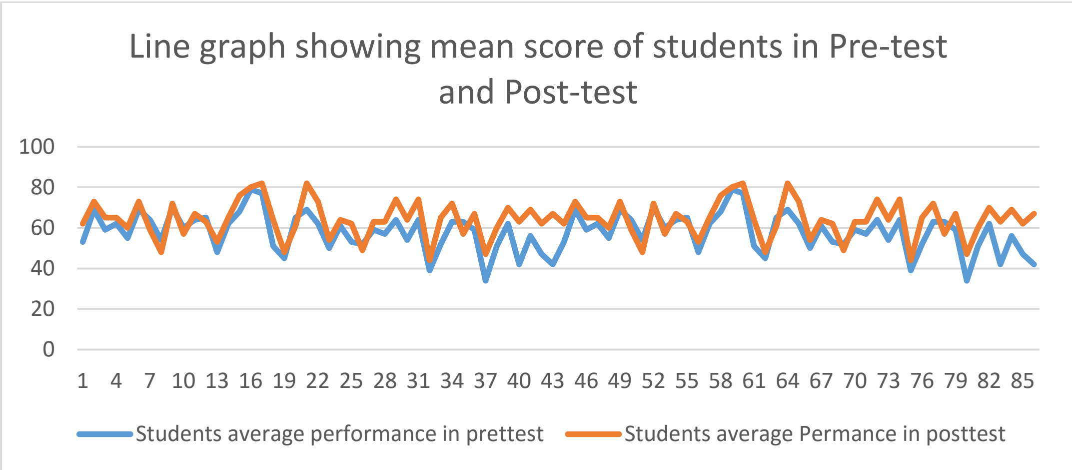


Figure 4.28: Trend graph for students observed scores in pretest and posttest

The analyses from trend graph in Figure 4.28 reveals that student performance in post test scores improved higher (with the orange colour) than the pretest scores (with blue colour). The boxplot in Figure 4.39 below further shows the weighted means for each chosen class based on the quartile range of each distribution.

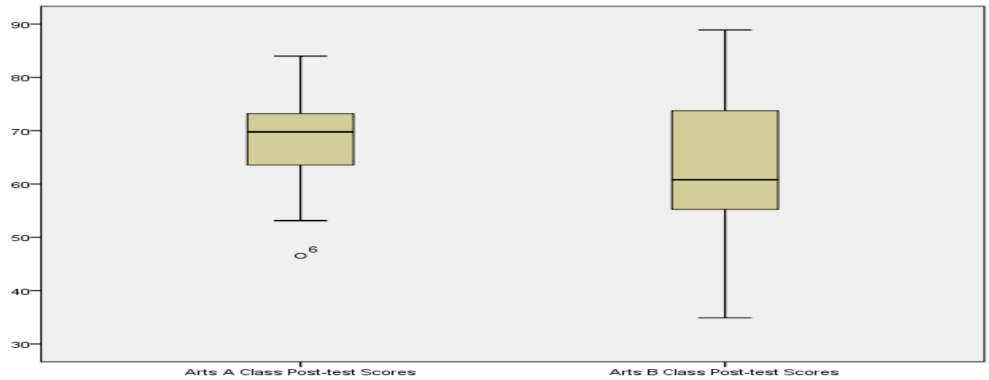


Figure 4. 29: Box plot of Students' Post-test scores

From the Boxplot in Figure 4.29, there is a fairly closed variability within Art A score than Art B. The average score of A is relatively higher than class B. Out of 100% scale rating, each class after the ethnomathematics class scored on the average more than 63%. Figure 4.30 further gives the normality assumption for post-test scores for the combined classes.

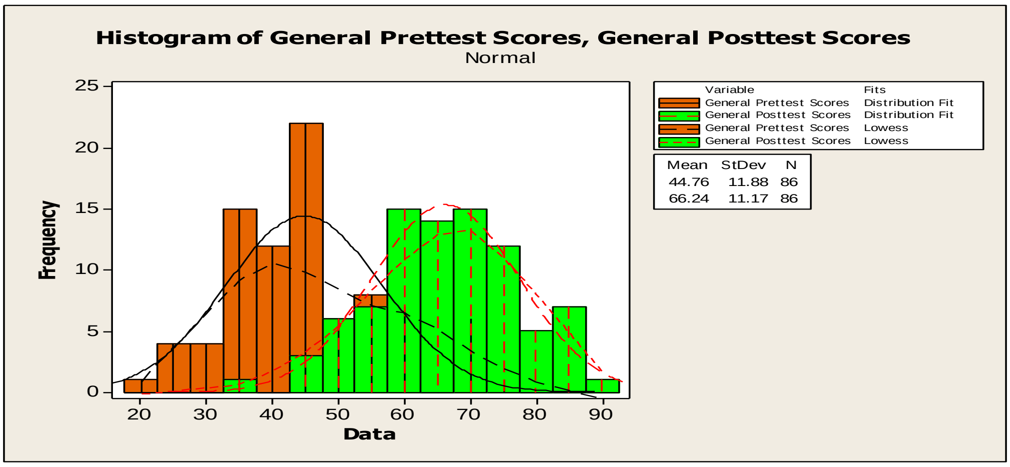


Figure 4. 30: Normality assumption of combined class post-test scores

From Figure 4.30, the variability associated with the normality assumption for post-test scores is higher than that of the pre-test scores for the selected combined class means. Students performed better in the post test scores after the ethnomathematics lessons than the pre-test scores.

4.4. Comparative Mean Difference Test for Pre-test and Post-Test Scores

This section gives a comparative mean difference test for the selected classes on the pre-test and post-test scores. Table 4.24 below gives the descriptive of the compared achievement scores of students from the respective classes with their combined means.

Table 4.24: Descriptive statistics of pre-test and post-test selected classes

		Mean	Combine mean	Std. Dev	Std. Error
Pair 1	Arts A Class Pre-test scores	46.94	44.76	15.064	2.297
	Arts B Class Pre-test scores	42.58		7.014	1.070
Pair 2	Arts A Class Post-test Scores	68.58	66.24	8.163	1.245
	Arts B Class Post-test Scores	63.90		13.214	2.015

From Table 4.24, a summary of descriptive for the means of pre-test and post-test scores for the two classes Art A and B are compared. The combined mean was estimated for the pre-test to be 44.76 compared to the post-test average combined mean of 66.24. There is an impact of the ethnomathematics lesson of marginal difference of 21.48% impact.

4.4.3 Significant test for mean difference between students pre and post test

In order to take an inferential decision on this, there is the need to investigate further whether the mean difference is significant as analyzed in Table 4.25.

Table 4.25: Paired sample Test for pre-test-post test for paired A and B

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Arts A Class Pre-test scores - Arts B Class Pre-test scores	43.66	10.538	1.607	1.123	7.609	2.717	42	.010
Pair 2	Arts A Class Post-test Scores - Arts B Class Post-test Scores	46.81	9.151	1.396	1.865	7.498	3.354	42	.002

Table 4.25 compares the pre-test and post-test results of the students within the experimental group in classes A and B. The results showed an improvement in students understanding of the lessons in the post-test scores. The mean difference for pre-test

score was 43.66 whiles that of post-test score was 46.81. The ability level for each class is fairly stable for pre-intervention and post-intervention lessons. There is an increase of 21.48% from pre-test score to the post-test score. This is an indication that in the post-test, every student‟s performance had increased in the experimental group. This improvement in scores might be due to the use of the ethnomathematics approach of teaching selected mathematical concepts to the class.

To ascertain whether or not the difference observed in the means is statistically different or significant, a paired samples t-test was conducted to compare the pre-test and post test scores. To test the null hypothesis that there is no significant difference between the pre-test and post-test performance of students taught with ethnomathematics method. Table 4.25 presents the results of the paired samples t-test on the pre-test and post-test performance of students taught with ethnomath method. There was statistically significant differences in means of students observed scores in the pre-test and posttest scores. It is confirmed from the inferential statistics under the t-test assumption that, the difference observed from the pre-test and post-test scores of the students before and after the ethnomathematics approach of teaching revealed a significant impact as reflective in the significant mean difference. A further correlation is explored as seen from Table 4.26.

Table 4.26: Mean and correlation analyses for individualize classes

		Mean	N	Std. Deviation	Std. Error Mean	Correlation	sig
Pair 1	Arts A Class Pre-test scores	46.94	38	15.064	2.297	0.760	0.000
	Arts A Class Post-test Scores	68.58	48	8.163	1.245		
Pair 2	Arts B Class Pre-test scores	42.58	38	7.014	1.070	0.816	0.000
	Arts B Class Post-test Scores	63.90	48	13.214	2.015		

From Table 4.26, each selected classes mean score in the pre-test was compared with their post-test and the correlation between individual students‟ scores is measured significantly. The mean difference of about 21.6% is an indication that, ethnomathematics approach of teaching can have positive impact on student academic achievement. The Pearson moment correlation coefficient in each respective class was calculated to be 0.76 and 0.816 respectively. The correlation is significantly strong and positive. The nature of the direct correlation shows the individualized student ability level which was proportionately influenced by the ethnomath approach. That is, a weak score in the pre-test proportionately correspond to fairly increase weak score in post-test while a higher achiever in the class with high score in pre-test proportionately increases his or her score fairly in the post-test. Evidence from Table 4.27 is an inferential significant test for comparing means for each class under the t-test statistics.

Table 4.27: Paired sample Test for pre-test-post test for respective classes

		Paired Differences					t	df	Sig. (2-tailed)
		Mean diff	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Arts A Class Pre-test scores - Arts A Class Post-test Scores	21.63	10.323	1.574	-24.814	-18.460	-13.74	37	.000
Pair 2	Arts B Class Pre-test scores - Arts B Class Post-test Scores	21.32	8.516	1.299	-23.943	-18.701	-16.41	47	.000

Table 4.27 further compares the pre-test and post-test for each respective class. The mean difference of 21.637 and 21.322 for each respective class were observed to be significant at $\alpha = 0.05$. The pairwise $t - test$ statistics for each class $(x_i - y_i)$ were -13.744 and -16.42 and were tested to be significant at 1%, 5% and 10% levels.

Figure 4.31 gives the normality assumption for the compared class performance achievements.

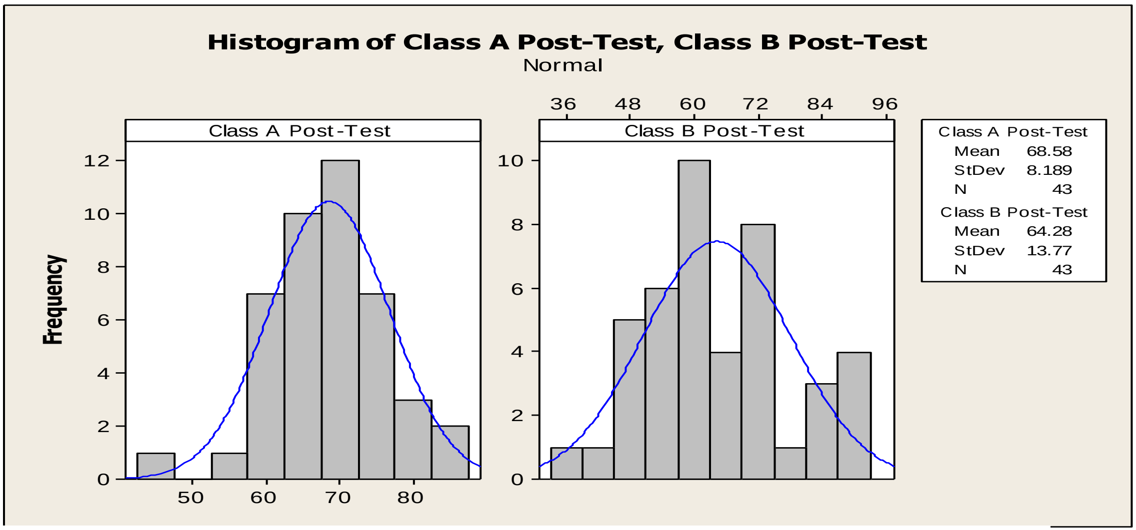


Figure 4.31: Normality assumptions for post-test scores for respective classes

From Figure 4.31, the normality assumption associated with the post-test scores for selected classes Arts A and B is specified with super-imposed skewness and kurtosis. Each of the post-test class scores are normally distributed with majority of the class scoring above the normal conventional average of 50%.

Table 4.28 gives independent samples test for equality of means and variance for obtained scores under t-test assumption for known and unknown variances respectively.

Table 4.28: Paired Samples t-test for equality of means and variance for obtained scores.

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Diff	Std. Error Diff	95% Confidence Interval of the Difference	
									Lower	Upper
Class A Obtained Scores	Equal variances assumed	19.182	.00	8.236	84	.000	21.5	2.61	16.33	26.734
	Equal variances not assumed			8.236	64.83	.000	21.5	2.61	16.31	26.75
Class B-Obtained Scores	Equal variances assumed	18.355	.00	9.391	84	.000	21.4	2.28	16.88	25.95
	Equal variances not assumed			9.391	64.15	.000	21.4	2.28	16.86	25.97

Table 4.28 also gives independent sample t-test inferential statistics for post test scores in each class; cases where each class variance is assumed to be equal or not equal. The differences in mean again are respectively significant under the assumption of the *t-test* statistics. The Fisher estimator is also computed to be significant with 19.18 and 18.36 for the pre-test score in A and B under the assumption of Levene‟s test for equality of variances. Similar analysis for comparing equality of means and variance is seen from Table 4.29 for ANOVA analyses from MINITAB output.

Table 4.29: One-way ANOVA for treatment classes

Source	DF	SS	MS	F	P
Factor	3	20945	6982	52.38	0.000
Error	168	22392	133		
Total	171	43337			

S = 11.54   R-Sq = 48.33%   R-Sq(adj) = 47.41%

```
                                   Individual 95% CIs For Mean Based on
                                   Pooled StDev
Level                 N   Mean  StDev  -+---------+---------+---------+--------
Class A Prettest   38  47.05  15.06      (--*---)
Class B Prettest   48  42.56   7.05  (---*--)
Class A Post-Test  38  68.58   8.19                        (---*--)
Class B Post-Test  48  64.28  13.77                      (--*---)
                                   -+---------+---------+---------+--------
                                   40        50        60        70
Pooled StDev = 11.54
```

Table 4.29 gives Analyses of Variance (ANOVA) for all assessment mode of students‟ performances for all selected classes. The estimated f-test value of 52.38 was significant for the p-value of 0.0000 compared to $\alpha = 0.05$. From the individual 95% confidence intervals for the mean, based on a pooled variance of 11.54. It is seen from the gridline graph that; the pre-test scores are clustered between 40% to 50% (a weak score). in comparison to the post test mean CI lying within 60 to 70%, we observe a very good performance achievement after the ethnomathematics approach of teaching. The performance is good when we teach with ethnomath approach. Figure 4.32 below extends a pictorial representation of the nature of individualized students‟ scores in the various assessments.

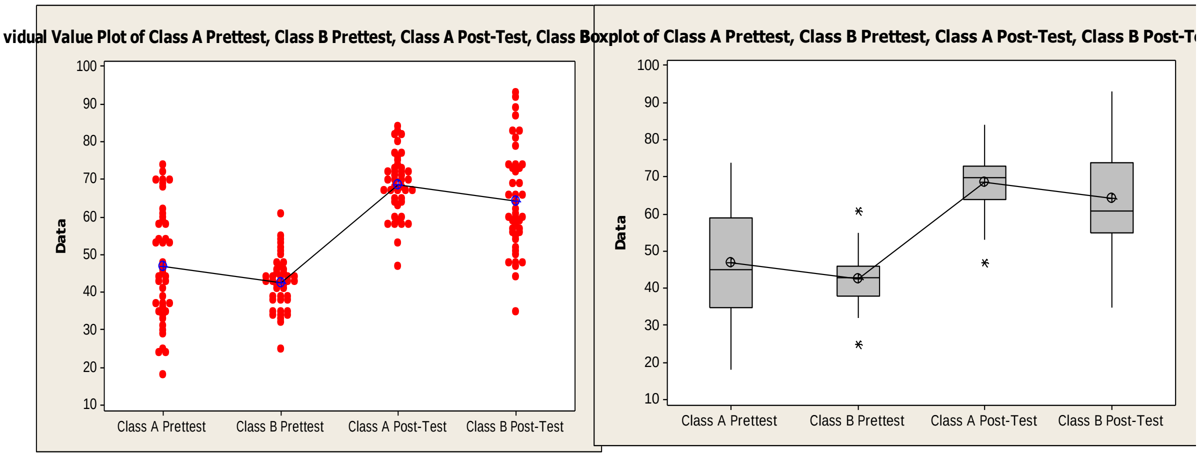


Figure 4. 32: Individualized Value plot for students' academic achievement.

Figure 4.32 gives individual value plot of classes A and B pre-test and Post-test scores with observed class boxplot for quartile ranges. The study observed the means of each class in the post test scores above par as compared to pre-test scores.

Several ethnomathematics researchers conclude on the positive impact of ethnomathematics approach of teaching (Pun 2019; Rosa, 2016; D"Ambrosio, 2001; Forbe, 2018; Kati, 2018). Teaching from cultural context where students are familiar with Realistic Mathematics Education (RME) makes lesson meaningful to students, (Puni, 2018). This undoubtedly increases students" performance, leading to quite appreciative academic achievement.

4.5 Research Question 4:

What are Teachers' and students' perceptions on the effectiveness and usefulness of ethnomathematics integration in teaching and learning of school mathematics?

Ethnomathematics integration in teaching and learning processes are perceived by teachers and students in divergent perspective. The application of ethnomathematics approach in teaching has little formal enforcement to curriculum implementations. This study inquired from teachers and students their perceptions and view on the usefulness and effectiveness of ethnomathematics integration in teaching and learning of mathematics. Data collection and analyses is based on teachers and students response to questionnaire guide as seen from Appendix E.

Some of the African countries have accepted fully, the implementation of ethnomathematics approach in teaching mathematics and have formal suggestive modes of using ethnomath in the lesson planning, teaching and learning of formal mathematics in school systems. For example, a study conducted by some African ethnomathematics researchers (Buchori, Sudargo, & Budiman, 2016; Michael & Ekpe, 2017; Alkhudair, 2019; Orim & Uzoma, 2019; Sunzuma & Maharaj, 2019) have considered the way ethnomathematics is perceived differently by mathematics educators.

The study inquired from teachers through questionnaire, the extent and nature of their awareness of ethnomathematics and whether they perceived its application to teaching and pedagogical development as worthwhile approach in teaching or otherwise. Hence the subsequent descriptive and inferential analyses from Tables and Figures (graphs) explores teachers‟ perception of ethnomathematics integration in teaching and learning of mathematics. Tables and graphs are based on quantitative analyses where descriptive and inferential statistical data analyses and decisions are given in this section to aid our answer to the research questions four.

In this section, a further exploration into students‟ and teachers‟ perception of integrating ethnomathematics approach in teaching is given. Students were exposed to various ethnomathematical activities from Akan communities to establish meaningful teaching. Their exposal to Akan ethnomathematics might however be different from what their class teachers might be using to teach them form the most popular expository method of Ghanaian teaching approach (Larson, 2007; Mereku, 2004). Apart from teachers‟ use of ethnomathematics approach in teaching, Ghanaians have peculiar scientific cultural way of expressing themselves differently that might perhaps throw ethnomathematical ideas to children in schools and in the community (Mereku, 2015).

The quasi-experiment of ethnomathematics approach in teaching selected mathematical concepts necessitated the need to interview students and enquire from them their perception of ethnomathematics integration in teaching and learning process through questionnaire.

4.5.1 Teachers Perceived effect of ethnomathematics integration in teaching and learning process

The study analyses the descriptive and inferential data on the collected response in this sub-section on teachers and students" responses questionnaire relating to the perceived effect of ethnomathematics integration in school mathematics teaching. The quantitative analyses is given to their views and perceptions.

Tables 4.30 gives the teachers perception on the effect of ethnomathematics integration or approach on the teaching and learning of school mathematics.

Table 4.30: Teachers Perceived effect of ethnomathematics integration in teaching and learning process

Average scaling of Effect	N	Mean		Std. Dev.
	Statistic	Statistic	Std. Error	Statistic
Perceived effect on the use of Ethnomathematics Approach integration on lesson planning	112	3.16	.043	.455
Perceived Effect of Ethnomathematics Approach in Teaching Mathematical Concept	112	3.73	.041	.431
Perceived Effect of Ethnomathematics approach on Students" Academic Achievement	112	3.99	.048	.503
Perceived effect on the use of Ethnomathematics Approach on assessment criteria	112	3.37	.038	.404
Perceived effect on the use of Ethnomathematics Approach on Curriculum development and implementation	112	3.25	.045	.475
Valid N (listwise)	112			

Source: field data 2020

Table 4.30 gives teacher perception of the effect of ethnomathematics approach in teaching and learning of mathematics. Respondent teachers were asked the extent to which they Perceive effect of the use of Ethnomathematics Approach on various levels of teaching mathematics such as planning the lesson, carrying out the teaching and pedagogical actions, assessment of the students, nature of students‟‟ achievement for the purpose of curriculum development and implementation. Responses were measured on the bases of Likert‟‟s scale rated from 0-5. The weighted averages for all response were marginally equal and approximately above scale of 3 (an above average rating).

The implication of the use of ethnomathematics approach in teaching is rated well by the 112 teachers sampled to have some effect on the way mathematics lessons are planned. It also has effect on resourceful teaching through appropriate pedagogical action. Students‟‟ assessment and performance achievement is rated to have a positive impact on them. In addition, teachers generally agree to the fact that ethnomath is to be considered in curriculum development and implementation processes. Table 4.31 below also gives students perception of ethnomath integration on the teaching and learning of school mathematics.

Table 4.31: Students perceived effect of ethnomathematics approach on learning of mathematics

Average scaling of effect	N	Min	Max	Mean	Std. Dev
Usefulness of ethnomathematics to students learning.	86	3.60	4.40	4.0372	.15647
Positive perceptual effect of ethnomathematics on students learning	86	3.00	5.00	3.9213	.30701
Negative perceptual effect of ethnomathematics on teaching and learning	86	1.50	2.50	1.9606	.15350
Valid N (listwise)	86				

Source: field data 202

Table 4.31 gives student perceived effectiveness of ethnomathematics approach on their learning and to further investigate whether the nature of the perception of ethnomath is positive or negative. Out of 86 students sampled, an average rating scale of 4.4 perceive ethnomathematics approach of teaching them as useful. There was an average of 3.92 Likert scale rating for whether the nature of ethnomath effect teaching and learning positively. This implies that, things associated with ethnomathematics integration to teaching and learning favours them proportionately. On the other hand, 2.5 mean response averagely rated it as negative, that is, it does not favour them so much as compared to the conventional approach used to teach them by their class teachers.

4.5.2: Participants opinion to interview on the effect of ethnomath approach of teaching on understanding mathematical concepts

The study probed further to investigate the effect and usefulness of the ethnomath approach through interview with some of the students below as seen from the structural model below. This study gives a further analyses using structural modelling on students responses during interview on how ethnomathematics integration from informal perspective links the formal mathematics concept teaching based on (Peni, 2019) theoretical and conceptual model in Figure 4.33 below.

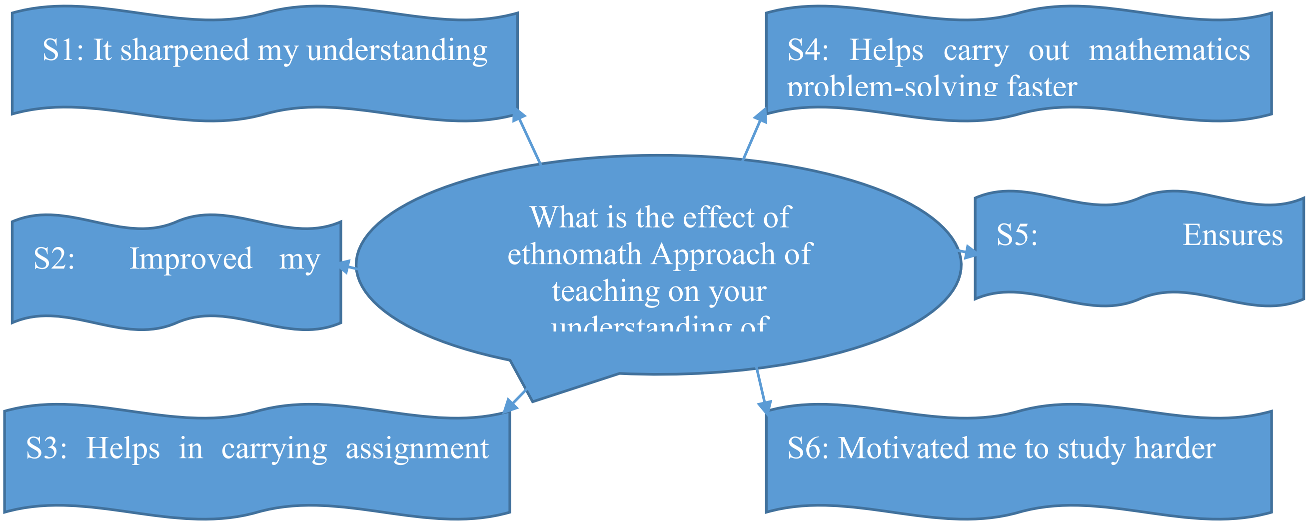


Figure 4.33: Students thematic response to interview on the perception of effect of ethnomath Approach

Students (S_i) were interviewed on their perception of the effect of ethnomathematics approach in teaching mathematical concepts on their understanding level from the experimental lessons. All the 6 interviewed students‟ responses surround positively on helping them to understand the concepts taught such as mensuration. Student respondent 2 (S2) view its effect as improving their academic performance as evident from inferential analyses on significance mean different test from pre-test and post-test scores obtained in research questions 3. Other students‟ respondents say it helped them in carrying out their assignment and project work more easily (S3), help in building their mathematics problem solving (S4), ensures cooperate learning with meaningful understanding (S5) and motivate them to learn harder than as before (S6).

Table 4.32 below investigate teachers‟ awareness of ethnomathematics approach towards the mathematics education system.

Table 4.32: Awareness of Policy on the Use of Ethnomathematics Approach in Curriculum

	Strongly Disagree	Disagree	Agree	Strongly agree	Not Sure
More than 50% of teachers consider ethnomathematics pedagogy	6(5.4%)	26 (23.2%)	44(39.3%)	31(27.7%)	5 (4.5%)
CRDD should consider ethnomathematics greatly when developing math syllabus	1 (0.9%)	2 (1.8%)	56(50%)	38 (33.9%)	15 (13.4%)
Teachers" choice of ethnomath is based on improvisation	1 (0.9%)	2 (1.8%)	64 (57.1%)	22(19.6%)	23(20.5%)
Students prefer teachers" choice of ethnomath integration in teaching	31(27.7%)	1 (0.9%)	19 (17.0%)	65 (58.0%)	26 (23.2%)
TOTALS	112 (100%)	112 (100%)	112 (100%)	112 (100%)	112 (100%)

Source: field survey 2020

The study inquired from Table 4.32, a further probe into the awareness of policy on ethnomathematics approach in teaching the mathematics that is in the curriculum implementation process. Majority were not sure whether more than 50% estimated number of teachers considers ethnomathematics pedagogy in lesson development. Every mathematics educator thinks about himself or herself in designing the most possible methodology best to suit the art of teaching. Majority 56 (50%) agreed on the need for CRDD to consider ethnomathematics greatly in the development of the syllabus. The other half percentage were not sure of the response. A few 3 (2.7%) disagreed. As already discussed, teachers" choice of ethnomathematics is greatly based on the decision to consider it as improvisation. Resourceful teaching through improvisation is greatly looked at by several authors (Abdul-Raheem, 2015; Adu, 2014; Holdhus, Høisæter, et al., 2016; Holdhus, Vangsnes, et al., 2016; Merrian & Bierema, 2013; Okori & Jerry, 2017).

Culturally relevant pedagogical teaching in diversity of socio-cultural settings demands a critical survey of the learners environment (Barton, 1996; Dahl, 2006). No wonder majority of the responding teachers sees or perceives ethnomathematics approach in the pedagogical development as a search for improvisation. The search of teaching and learning materials (TLMs) is the concern of most Ghanaian teachers. The Figure 4.34 below shows teachers perception on it.

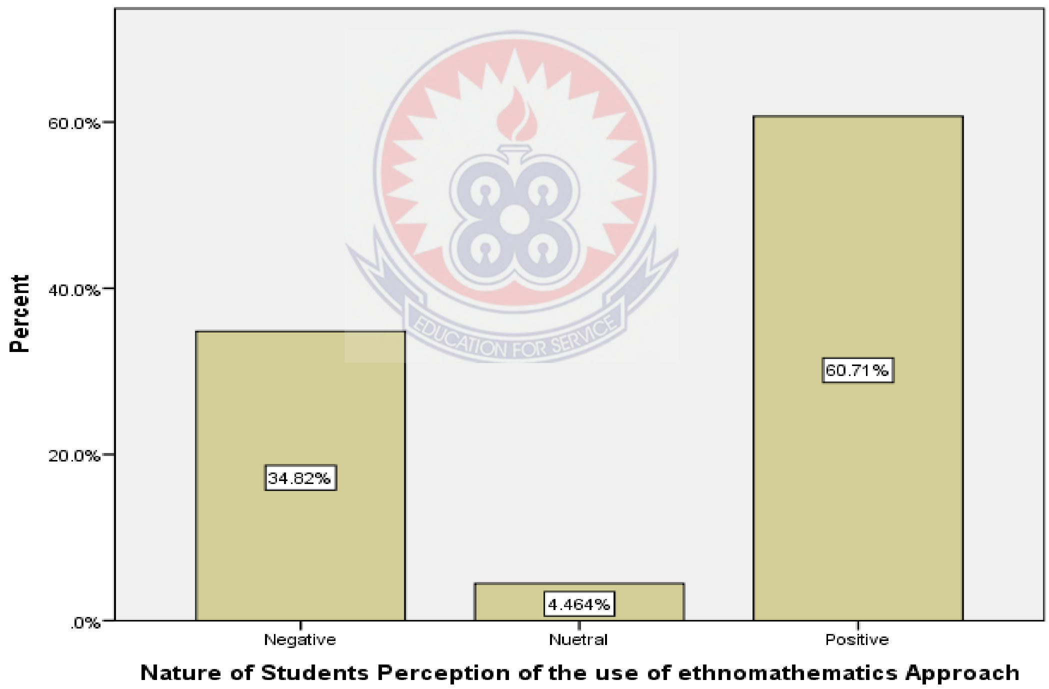


Figure 4.34: Nature of students perception of ethnomathematics

Figure 4.34 gives bar chart of the nature of students‟ perception of the use of ethnomathematics approach in teaching them. The modal bar reflects positive perception of 60.71% whiles 34.82 perceive it as negative. The negation is probably influenced by delaying the completion of the syllabus. On the other hand, 4.48% were not sure of their response implication.

Table 4.33 below shows the nature of students' perception of Ethnomathematics integration in teaching in relation to their interest in studying school mathematics

Table 4.33: Nature of students' perception of Ethnomathematics Integration in Teaching and their interest in studying Mathematics

		Students Interest status on the use of Ethnomathematics Approach in teaching them						
		High uninterested	Uninterested	Not sure	Interested	Highly Interested	Inferential statistics Pearson Chi-square	
Nature of Students Perception of the use of ethnomathematics Approach	Negative	0	0	15	22	2	χ^2	31.756
	Neutral	0	1	1	2	1	d.f.	8
	Positive	2	0	28	38	0	Sig.	.000*

Source: field data 2020

The study forwarded further inferential statistical analyses on cross tabulation chi-square significant test for perception of students on integration of ethnomathematics approach in the curriculum implementation process (teaching and learning of mathematics). This investigation looked at whether their interest in ethnomathematics is independent of their perception on ethnomathematics integration in teaching them. Table 4.33 gives a Pearson chi-square inferential statistic defined in 3×5 contingency Table 4.33 above. An estimated chi-square value of 31.756 was statistically significant at $\alpha = 0.05$. The cross tabulation was to confirm the hypothesis on research question five that;

H_0: Students interest in mathematics lesson is independent on their perceptual disposition on ethnomathematics integration in formal mathematics lesson.

H_1: Students interest in mathematics lesson is dependent on their perceptual disposition on ethnomathematics integration in formal mathematics lesson.

The chi-square $(\chi^2) = 31.756$ is significant at $\alpha = 0.05$, we fail to reject the H_0 and conclude the H_1 is false. Hence our conclusion points to the fact that students‟ interest in mathematics lesson is independent on their perceptual disposition on ethnomathematics integration in formal mathematics lessons. That is the fact that a student has interest in mathematics lesson does not guarantee that it is because of teachers‟ choice of ethnomathematics approach in teaching them.

Several factors might be contributing to their interest in the lesson. Such factors according to (Bezek, Kayri, & Erdoğan, 2019; Güre, Kayri, & Erdoğan, 2019.; Kaleli-Yilmaz, 2015; Sezgin, 2017) could be teacher related factors, environmental related factors, school related factors and among other factors.

4.5.3 Mathematics Teachers' and Students' perception on the Usefulness of Ethnomathematics Integration in teaching and Learning of School Mathematics?

Ethnomathematics integration in teaching and learning processes are perceived by teachers in divergent perspective. The application of ethnomathematics approach in teaching has little formal enforcement to curriculum implementations. The study inquired from teachers and students their perceptions and view of integrating ethnomathematics approach in teaching mathematics based on its usefulness. Data collection constituted participants‟ response to guided questionnaires and interviews. The analyses is organized in the form frequency distribution Tables and Figures where appropriate.

Some of the African countries have accepted fully, the implementation of ethnomathematics approach in teaching mathematics and have a formal suggestive mode of using ethnomath in the lesson planning, teaching and learning of formal mathematics in school systems. For example, a study conducted by some African ethnomathematics researchers, (Buchori, Sudargo, & Budiman, 2016; Michael & Ekpe, 2017; Alkhudair, 2019; Orim & Uzoma, 2019; Sunzuma & Maharaj, 2019) have considered similar ways ethnomathematics is perceived differently by mathematics educators.

4.5.4 Teachers perceived usefulness of ethnomathematics integration in learning of mathematics

The study inquired from teachers through questionnaire, the extent and nature of their awareness of ethnomathematics and whether they perceived its application to teaching and pedagogical development as worthwhile approach in teaching or otherwise. Hence the subsequent descriptive and inferential analyses from Tables and Figures (graphs) explores teachers‟ perception of ethnomathematics integration in teaching and learning of mathematics based on its usefulness. Tables and graphs are based on quantitative analyses where descriptive and inferential statistical data analyses and decisions are given in this section to aid our answer to the research questions five.

Table 4.34 below shows teachers perceived usefulness of ethnomathematics integration in the teaching of school mathematics.

Table 4.34: Teachers perceived Usefulness of Ethnomathematics Integration in Teaching Mathematics

Average Perceptual view	N	Minimum	Maximum	Mean	Std. Dev.
Teachers Perceived usefulness of ethnomath in Teaching Math	112	1.17	5.00	3.6801	.53978
Perceived usefulness of ethnomath integration in Teaching	112	1.20	4.47	3.7440	.42083
Valid N (listwise)	112				

Table 4.34 provides teachers perception of the usefulness of ethnomathematics approach as integration in the teaching and learning of mathematics. Two broad themes were transformed and descriptives computed. Each theme hard about seven issues inquired from teachers: (1) „teachers perceived usefulness of ethnomath in teaching mathematics" which realized a minimum rating of 1.17 and a maximum rating of 5 with mean of 3.68. The second is on (2) „perceived usefulness of ethnomathematics integration in the teaching process" with a minimum rating of 1.2, maximum rating of 4.47 and a mean Likert rating of 3.74.

The average weighted ratings of all the themes discussed investigated on the usefulness of ethnomathematics and its integration in the teaching of mathematics seem to have an above average Likert scaling response. It is believed by majority of the sampled teachers that, ethnomathematics approach, when used or integrated in the teaching approach is useful in bringing about good pedagogical processes in the teaching and learning encounter.

4.5.5: Student perceived usefulness of ethnomathematics integration in learning of mathematics

The study proceeded to find out from student their perception about the same phenomenon on the usefulness of ethnomath approach of teaching as seen from Table 4.35.

Table 4.35: Student perceived usefulness of ethnomathematics integration in learning of mathematics.

Average Perceptual view	N	Minimum	Maximum	Mean	Std. Dev.
Students Perceived usefulness of ethnomath integration in Teaching	86	1.01	4.57	4.7440	.12083
Students Perceived usefulness of ethnomath in learning mathematics	86	3.60	4.40	4.0372	.15739
Valid N (listwise)	86				

Source: fieldwork 2020

Table 4.35 gives students response to the perceived usefulness of ethnomathematics integration in teaching and learning school mathematics. The various responses of students were transformed into two broad themes: (1) students perceived usefulness of ethnomathematics integration in teaching‟ mathematics and (2) students perceived usefulness of ethnomathematics approach in learning mathematics‟. The combined students‟ responses from the two classes Arts A and B reacted to their perception after they have been introduced into the experimental lessons on ethnomathematics. Each class constituted 43 students given a total 86 respondents. On the perception of usefulness of ethnomath integration to teaching, the minimum rating was 1.01 and maximum being 4.57 with a mean of 4.744 which is of high rating. In the same way, „students‟ perceived usefulness of ethnomath in learning mathematics had a minimum of 3.6 and maximum Likert rating of 4.4 with a mean of 4.04 which is highly rated.

Students‟ response on the usefulness of ethnomathematics to both teaching them and their response to learning was rated higher among the 86 sampled students. This means that, student saw the ethnomathematics approach in teaching them as prudent and worthwhile is facilitating their response to learn the mathematics with clearer understanding. Table 4.35 further investigate the effect of ethnomathematics approach on students learning and academic achievement.

The interview below was to inquire further students‟ view of usefulness and effect of ethnomathematics integration in the teaching and learning process based on the experimental lessons.

Researcher: How different was this teaching methods with me (researcher) from what you usually experience with your usual teachers?

Interviewee 1: This one allows us to explore the environment. You know we used so many materials

Interviewee 2: The lessons were full of resources and materials and I like the group learning

Interviewee 3: Wow! The lesson was full of materials we interacted with. Team learning was good for me

Researcher: How useful is the integration of Ethnomath approach in teaching the mathematics experimental lesson to you?

Interviewee 1: Helped me to understand what we learnt more. We covered a lot of things too.

Interviewee 2: Hmmm! I like the way you (researcher) teach. It helped me to understand only that I couldn"t figure out the last example. All the same the previous lessons were good

Interviewee 3: If we are to be exposed to such teachings, it will help me to pass WASSCE.

Students" response generally appreciated the usefulness of the ethnomathematics strategies used for teaching them. They conceived the approach as full of resourceful based teaching strategy. Researchers are of the view that mathematics teaching at times need improvisation (Abdul-Raheem, 2015; Adu, 2014; Holdhus, Høisæter, et al., 2016; Merrian & Bierema, 2013; Okori & Jerry, 2017). Teaching strategies that adopt materialistic approach of teaching have been confirmed to be successful. Ethnomath approach demands such culturally relevant resourceful teaching. This helped build the students understanding of the experimental lessons which is consistent with (Merrian & Bierema, 2013; Okori & Jerry, 2017).

Descriptive statistics on students" perception of ethnomath effect on their understanding of formal school mathematics is presented in Table 4.36.

Table 4.36: Descriptive Statistics on effects of ethnomathematics to students

Average scaling of Effect of ethnomath approach	N	Minimum	Maximum	Mean	Std. Dev
Ethnomathematics approach used in the lessons improved my performance in the lessons (A)	86	1.00	5.00	4.023	.66822
My average score improved more than my previous term score (B)	86	3.00	5.00	4.209	.51143
It has increased my mathematical thinking (C)	86	4.000	5.000	4.186	.391427
It has increased my mathematical understanding (D)	86	3.00	5.00	4.232	.47711
Valid N (listwise)	86				

Table 4.36, presents the effect of ethnomathematics approach to students learning and academic achievement inquired from them after the experimental lesson. Out of 86 students sampled, a Likert scale was rated by students from 1 to 5 being the minimum and maximum respectively to students‟ questionnaire. Item A suggest whether students‟ academic performance was improved after the experimental lesson with the ethnomathematics approach. A minimum one (1) and maximum five (5) was realized with a mean scaling of 4.023 which is above average.

Theme (B) enquires whether students‟ average was improved than their previous terms average score. This had a minimum of 3 and a maximum of 5 with mean rating of 4.21. This means that, the experimental lesson appreciated students‟ academic performance and the impact is well specified. This consistent with the afore discussed inferential statistics on the significance difference of means of pre-test and post test scores from the experimental classes.

From theme C, students were asked from the Likert scale whether ethnomathematics approach used in teaching the selected topics improved their mathematical thinking. On the similar scaling, a minimum of 4 and a maximum of 5 with a mean of 4.2 was realized. This also implied that students" mathematical thinking was improved whenever they are exposed to teaching that links their priori knowledge from their environment and culture. This is in consolidation of what the constructivist theory suggests when the ethnomath approach put students in their "Zone of Proximal Development, (ZPD)", (Smith, 1992; Volmink, 1990; Wilkinson & Shank, 2019). This was confirmed by the study conducted by, (Teye, Narh Tetteh, et al., 2018) as he sees cultural effect of students learning and critical thinking skill from their adaptive environment. The work of *sociocultural theory* is to explain how individual mental functioning is related to cultural, institutional, and historical implications as a fundamentally new approach to the problem that learning should be matched in some manner with the child's level of development. The theory constitutes a transmission meanings model on *„the participation model of cultural development"*, (Scott & Palincsar, 2018)

From theme D, students were again inquired whether the use of ethnomathematics approach in teaching them „increase their mathematical understanding". A minimum of 3 and a maximum of 5 with a mean scale rating of 4.2 was realized. This consistent with the already discussed effect of ethnomath on their academic performance and achievement. For their academic work to be improved, their level of understanding is quite pivotal. This is consistent with the findings of (Rosa & Orey, 2016) on the essence and usefulness of ethnomathematics integration in teaching formal mathematics.

4.6: Research Question 5:

What is the effect of ethnomathematics approach to teaching mathematics on students' interest and motivation in studying selected topics in Ghanaian core mathematics curriculum?

As discussed so far on the various Akan ethnomathematics existing from informal position, investigating its effect on students‟ interest and motivation to learn mathematics is paramount. The analyses in this section explores research question 5 on the bases of how application of ethnomathematics approach in teaching school mathematics can affect students‟ interest as well as motivation in studying mathematics. Data analyses is based on teachers and students‟ response to questionnaires on the theme of *„interest and motivation associated with ethnomathematics"* as seen from Apendix E and F The analyses and results are organized into frequency distribution based on Likert scaling, graphs, interview guide responses and structural models.

Students‟ interest in studying mathematics has been explored by many and sundry researchers as mostly skewed to dislike and negative attitude towards its learning (Auliya, 2019). This undoubtedly affect the Motivation and zeal to learn the mathematics. Several ethnomathematics philosophers have associated ethnomathematics approach in teaching mathematics to students motivational strategies to learn, and get interested to mathematics (Baumgartner & Spangenberg, 2018; Bayer, Klieme, Kaplan, & Vieluf, 2012; Budiarto, Artiono, & Setianingsih, 2019b; Fouze & Amit, 2018a, 2018b; Priyonggo & Wardono, 2019). This is quite absent in Ghanaian situation. Several motivational studies have been carried out in Ghana but are not associated with ethnomathematics surveys. There is the need to investigate students‟ interest and motivation with respect to how ethnomathematics strategies are connected to. This study investigated the intrinsic and extrinsic motivational response of students based on their exposal to ethnomathematics integration in the teaching and learning process.

The analyses in these sections and subsequent discussions take quantitative analyses form to establish findings. Both descriptive (in the form frequency distribution Tables and graphical representations) as well as inferential statistical analyses for decision making are surveyed. We assume the study discussions of inferential decision on a significance level of $\alpha = 0.05$

4.6.1: Teacher view on motivation associated with ethnomathematics

There is the need to investigate teachers‟ interest and motivation with respect to how ethnomathematics strategies are connected to their resourceful teaching. Table 4.37 below gives analyses on teachers view on how ethnomathematics integration in formal school mathematics teaching helps to build students interest and motivation in the learning of the subject.

Table 4.37: Teacher view on motivation associated with ethnomathematics

	N	Minimum	Maximum	Mean	Std. Dev
Ethnomath approach builds students‟ interest in studying mathematics	112	2.00	5.00	4.0625	.57393
Helps to involve the student in the teaching and learning process	112	1.00	5.00	4.1250	.63139
Ensures students maximum participation	112	1.00	5.00	4.1875	.74170
Helps in coorporate learning strategies	112	1.00	5.00	4.0179	.72263
Attraction of students‟ attention	112	1.00	5.00	4.2411	.87246
Ensures intrinsic motivation	112	1.00	5.00	3.9375	.97057
Ensures extrinsic motivation	112	2.00	5.00	3.5357	.70938
Students desire to participate in mathematics lessons	112	1.00	5.00	4.0893	.78904
Students desire to extend their learning hours	112	1.00	5.00	3.7679	.88003
Builds students affective domain	112	1.00	5.00	2.7857	1.14237
It makes students uncomfortable	112	1.00	5.00	1.2946	1.17511
ethnomathematics approach is one of the most important teaching strategies.	112	2.00	4.00	3.11	0.4501

Table 4.37 presents teachers view on the effect of ethnomathematics approach in teaching with respect to students‟ motivation to learn and participate fully in the lesson. Teachers‟ responses were measured along the magnitude of Likert scaling rated between 0-5. The more average responses close between 3-5, the stronger respondent view are. On the other side, 0-2 represent weaker evidence towards the response.

On whether Ethnomath approach builds students‟ interest in studying mathematics the average response was 4.06 which represents a high rating effect. Students were also asked whether ethnomath helps to involve the student in the teaching and learning process; a mean scale of 4.13 was estimated. Other motivation themes inquired were to ensure students maximum participation (4.19), helps in coorporate learning strategies (4.02), and whether it helps in attraction of students‟ attention (4.24). For other form of motivation, we inquire whether the ethnomathematics approach ensures intrinsic and extrinsic motivation on the part of students and teachers and realized average rating of 3.93 and 3.54 respectively. Students desire to participate in mathematics lessons was rated a mean of (4.09). Students desire to extend their learning hours was also rated an average of 3.8. on whether ethnomathematics „builds students‟ affective domain‟, a mean of 2.79 was seen. A low mean rating of 1.29 was realized for teachers‟ response on whether ethnomathematics approach „makes students uncomfortable‟. In the same way, teachers‟ response to whether „ethnomathematics approach is one of the most important teaching strategies‟, an above mean rating was computed to be 3.11.

From the analyses in Table 4.37, majority of the mean response pointed towards positive effect of the use of ethnomathematics approach towards teachers and students‟ motivation in the teaching and learning process.

4.6.2: Students' perception of motivation associated with ethnomathematics approach of teaching and learning.

Table 4.38 below presents students view on the effect of ethnomathematics approach towards their motivation to learn the selected concepts.

Table 4.38: Students' View on Motivation Associated with Ethnomathematics

Student Motivation	N	Minimum	Maximum	Mean	Std. Devi
Ethnomathematics approach is one of the most important teaching strategy.	86	2.00	5.00	4.0465	.43133
My mind goes blank and gets confused when studying mathematics	86	2.00	5.00	4.0233	.40517
Ethnomathematics approach helps me understand a mathematical concept	86	3.00	5.00	4.1395	.41053
Studying maths makes me feel nervous	86	1.00	5.00	3.2791	1.19461
Ethnomathematics make me feel comfortable with math	86	2.00	5.00	4.0233	.40517
When I hear the word mathematics, I have a feeling of dislike	86	2.00	5.00	3.9535	.43133
I am always confused in my mathematics class	86	1.00	5.00	3.9767	.55257
Good maths pedagogies like ethnomathematics approach could help me learn math well	86	2.00	5.00	3.9767	.40517
Teaching mathematics in a socio-cultural way would build my interest in learning	86	4.00	5.00	4.1628	.37134
My interest is built in studying mathematics with this new method of teaching.	86	3.00	5.00	4.0000	.30679
I have a carrier to build in studying mathematics	86	1.00	5.00	2.1395	1.32986
Valid N (listwise)	86				

Source: Fieldwork, 2020

Students responses to questionnaire were subjected to the usual Likert scaling of 0-5 as seen from Table 4.38. Total students sampled were 86, comprising two classes in which the experimental class was done using the ethnomathematics approach. When asked whether Ethnomathematics approach is one of the most important teaching strategies they have observed after the experimental lessons, an average scale of 4.05 was realized to be above mean. On whether „studying mathematics makes them feel nervous‟, there was a mean scaling of 3.28. There was a mean rating of 4.14 response for whether Ethnomathematics approach helps students understand mathematical concepts. On whether studying mathematics makes them feel nervous, there was a mean of 3.28. Students were asked whether Ethnomathematics make them feel comfortable or have dislike for the subject. A mean of 4.02 and 3.95 was estimated respectively to be also above average. Students‟ response was scaled 3.95 on whether they always get confused in mathematics class.

Good mathematics pedagogies like ethnomathematics approach could help students learn mathematics well is scaled 3.98. Students were also asked whether teaching mathematics in a socio-cultural way would build their interest in learning mathematics; a mean scale of 4.1 was computed. Also, whether students‟ interest is built in studying mathematics with this new method of teaching, a scale weighting average of 4.0 was computed to be above average. Few students were of the view of actualizing their motivational disposition by taking a carrier to build in studying mathematics, there was mean scale of 2.14. Majority interest is not on building a carrier in mathematics related programs in the university or any tertiary level they would seek to be enrolled. The perception attributed to ethnomathematics is seen similarly by some ethnomathematicians (Baumgartner et al., 2018; Bayer et al., 2012; Budiarto et al., 2019a).

4.6.3: Type of motivation perceived by students on ethnomathematics approach

The graph in Figure 4.35 shows the descriptive of the motivational types associated with ethnomathematics approach in teaching mathematics.

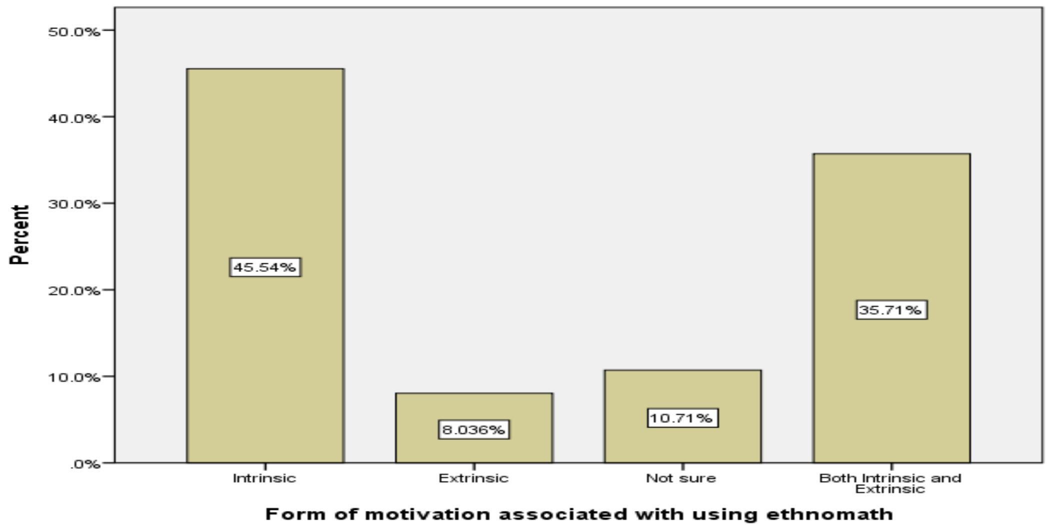


Figure 4.35: Bar graph showing form of motivations

The descriptive graph in Figure 4.35 represents the respondents view on whether the use of ethnomathematics approach in teaching and learning motivates them intrinsically or extrinsically, intrinsic have the modal bar of 45.54% followed by both motivational types of 35.71. Whiles 10.71 were not sure of the effect, the rest 8.036% believe there is extrinsic motivational effect of ethnomath on mathematics lesson. Table 4.39 gives further investigation on motivational effects on ethnomathematics.

4.6.4: Effect of motivation associated with the use of ethnomathematics approach

Table 4.39 summarizes the effect of motivation associated with the use of ethnomathematics approach

Table 4.39: Effect of motivation associated with the use of ethnomathematics *approach.*

Student Motivation	N	Minimum	Maximum	Mean	Std. Devi
Effect of teachers" motivation associated with the use of Ethnomathematics approach in teaching.	112	2.00	5.00	4.01	.431
Effect of students" motivation associated with the use of Ethnomathematics approach in learning	86	3.00	5.00	4.71	.405

Source: Field data 2020

The major themes under students and teachers‟ motivational responses were computed by using the SPSS variable computation and descriptive of mean measured. The mean scaling under Likert scale ratings from (0-5) were computed to be 4.01 for teachers out of 112 respondents. The students mean scaling was found to be 4.71, an above average aggregate scale.

From Table 4.39, the mean scale was above general average of 2.50. Majority of respondents‟ have positive perception of ethnomathematics effects on students and teachers‟ motivations respectively. This imply that ethnomathematics approach best motivate teachers and students in the teaching and learning encounter.

The structural model below is the various response themes when students and teachers were interviewed. The interview questions:

1. what effect does ethnomathematics approach of teaching has on students‟ interest in learning mathematics
2. what effect does ethnomathematics approach of teaching has on students‟ motivation in learning mathematics

Participants‟ responses are organized in the structural model below (in Figure 4.36) for various responses on these two interview questions.

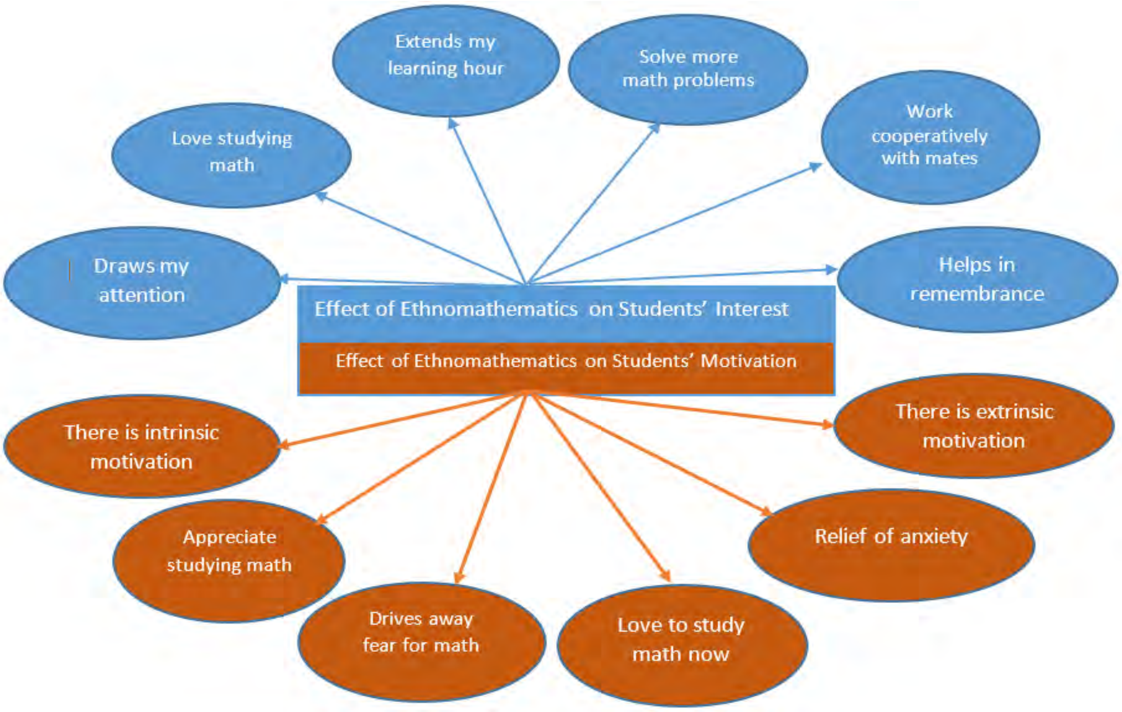


Figure 4.36: Structural interview model for effect of ethnomath on students' interest

Six (6) participants were interviewed on the effect of ethnomathematics approach on students‟ interest and motivations respectively in Figure 4.36. On the effect on students‟ interest, thematic responses were given as (1) drawing their attention and focus to study, (1) increasing their love for studying mathematics, (3) extend their learning hour, (4) helps them solve more mathematics problems, (5) helps in team building and corporative learning and (6) have given them positive perception of the mathematics.

Participants response to the effect of ethnomathematics approach on students‟ motivation were given as helping them both intrinsically and extrinsically, appreciating mathematics as a whole, drives away their fears for studying mathematics. It relief them of their negative anxiety and creates in them, a love for studying mathematics.

Table 4.40 further explore students" interest and motivation associated with ethnomath integration in the teaching and learning process to link formal and informal mathematics.

Table 4.40: Descriptive statistics of students' interest and motivation in ethnomathematics approach in teaching

	Strongly Disagree	Disagree	Agree	Strongly agree	Not Sure
Ethnomath approach builds students" interest in studying mathematics	1(0.9)	12 (10.7%)	78 (69.6%)	21 (18.8%)	0 (0.0%)
Helps to involve the student in the teaching and learning process	1 (0.9%)	1 (0.9%)	7 (6.3%)	77 (68.8%)	26 (23.2%)
To ensure students maximum participation	1 (0.9%)	3 (2.7%)	7 (6.3%)	64 (57.1%)	37 (33%)
Helps in Corporate learning	1 (0.9%)	1 (0.9%)	19 (17.0%)	65 (58.0%)	26 (23.2%)

Source: field survey 2020

Table 4.40 presents descriptive statistics of students" interest and motivation in ethnomathematics approach in teaching mathematics. Teachers" views on whether they agree or disagree to the questions stem directed towards students" interest and motivation were investigated. They agreed concisely by 78 (69.6%) that ethnomath interest students in the learning process as against 13 (11.6%) respondents who disagreed.

In the same way, whether ethnomath help involve students in the lesson process, two (1.8%) disagreed whilst 110 (98.2%) agreed. Students" involvement in mathematics lesson enhances maximum lesson participation. This can result in meaningful learning when appropriate pedagogical action is adopted by the teacher (D"Ambrosio & Rosa, 2017; Hanghøj, 2013). Teachers agreed to maximum participation by 63.4% of the total

112 respondents as against the rest 36.6% disagreeing. The study probed further whether the resultant of this maximum participation allows for corporative learning strategy when ethnomathematics approach of teaching is considered. In addition, 84 (75%) agreed whilst 2 (1.8%) disagreed. However, 26 respondents representing 23.2% were not sure of their position to agree or disagree.

In conclusion, majority indisputably perceived ethnomathematics approach of teaching and learning school mathematics as very interesting and motivating. It involves students in the lesson, ensures maximum students" participation and create means of cooperative learning skills. This is the current trend of teaching for which researchers request teachers adhere to in order to ensure fruitful teaching experience (Greene, 2000; Khan et al., 2015). Orey (2016) also attest to the fact that student"s interest and motivation is sustained when they learn mathematics through the eyes of ethnomathematics.

4.7: Research Question 6:

What problems are associated with the ethnomathematics integration in the teaching and learning of school mathematics.

The study investigates further on the problems associated with the use of ethnomath approach on the teaching and learning of school mathematics. It is seen from Table 4.41 that, majority of the respondents agreed that certain problems are associated with ethnomathematics method of teaching mathematics

Table 4.41 :Problems associated with the use of Ethnomath Approach in teaching

Problems	Str. Disagree	Disagree	Not sure	Agree	Strongly agree
It retards progression of teaching	13(11.6%)	33 (29.5%)	35(31.3%)	27(24.1%)	4 (3.6%)
It dulls the lesson	24(21.4%)	48 (42.9%)	13(11.6%)	23 (20.5%)	4 (3.6%)
Delays completion of syllabus	1 (0.9%)	3 (2.7%)	21 (18.8%)	62 (55.4%)	25 (22.3%)
Restrict students‟ inattentiveness	2 (1.8%)	3 (2.7%)	15 (13.4%)	73(65.2%)	19 (17.0%)
Ethnomath integration in teaching mathematics burdens teachers	2(1.8%)	15 (13.3%)	48(42.7%)	40(35.7%)	7 (6.3%)
Ethnomathematics involves a lot of improvisation	1 (0.9%)	6 (5.4%)	24(21.4%)	61 (54.5%)	20 (17.9%)
Ethnomath approach is tedious and difficult task	16 (14.3%)	41(36.6%)	26 (23.2%)	26 (23.2%)	3(2.7%)
It is difficult to apply ethnomathematics in classroom	19(17%)	35 (31.3%)	20 (17.9%)	34(30.4%)	4 (3.6%)
TOTALS	112 (100%)	112 (100%)	112 (100%)	112 (100%)	112 (100%)

Source: field survey 2020

Table 4.41 gives some pertinent problems associated with ethnomathematics approach of teaching. The study investigated from respondents‟ views on whether ethnomath integration in school mathematics teaching retards the lesson progression, dulls the lesson, delays the lesson and or restrict students‟ inattentiveness. On whether ethnomath retards teaching progress, 46 (41.1%) disagreed, 31 (27.7%) agreed and 35 (31.3%) were neutral. On whether it dulls the lesson, 72 (64.3%) disagreed, 13 (11.6%) were not sure whiles 27 (24.1%) agreed. On whether ethnomath delays the mathematics lesson, 4 (3.6%) disagreed, 21 (18.8%) were not sure of the effect whiles a whopping

87 (77.7%) agreed that it delays the completion of the syllabus. The study inquired again from the last segment of the table whether ethnomathematics restrict students" inattentiveness in class during mathematics lesson. 5 (4.3%) disagreed, 15 (13.4%) were not sure whiles 91 (82.2%) agreed.

It is seen from Table 4.41 that, majority of the respondents agreed that certain problems are associated with ethnomathematics method of teaching mathematics, but the extent to which this pedagogical action facilitate good implementation of the formal mathematics curriculum is enormous.

Table 4.41 probed further to investigate the awareness of existing policy on ethnomathematics. The first segment of Table 4.30 asked respondents whether their integration of Ethnomath integration in teaching mathematics burdens teachers. A valid response of 7 (15.2%) disagreed, 48 (42.9%) were not sure and 47 (42.0%) agreed. The syllabus exemplify to some extent, Realistic Mathematics Education (RME) as suggested by some ethnomathematicians (Azmi & Wardono, 2018; Sumirattana et al., 2017). The awareness of ethnomathematics approach needs to be advertised so as to make it known and popular to especially mathematics teachers in Ghana.

On whether ethnomathematics involve a lot of improvisation, majority, comprising 81 representing 72.3% agreed compared to 7 (6.3%) disagreeing whiles 24 (21.4%) were not sure. Since ethnomathematics is dominantly evident by artefacts, (Garegae, 2007, 2015; Rosa, Milton Shirley, Lawrence Gavarrete, Maria Elena Alangui, 2017; Sharma & Orey, 2017), it makes perfect exemplification of mathematics through improvisation of concrete artifacts. Respondent also agreed by cumulative 21 (25.9%) that ethnomathematics application and integration in mathematics lesson is quite tedious compared to 57 (50.9%) who disagreed to this assertion whiles 26 (23.2%) were neutral about their response. Finally, the last response term disagreed by 54 (%) that it is difficult to apply ethnomath in pedagogical development of their lesson. 20 (17.9%) were not sure whiles 38 (33.9%) agreed.

In a nut shell, the awareness of ethnomathematics approach in teaching mathematics is there only that, majority of the respondents see it as quite difficult to apply in the pedagogical development of the lesson throughout the curriculum implementation process. Figure 4.37 shows teachers response to reasons that inform them to consider ethnomathematics integration into the teaching and learning of school mathematics

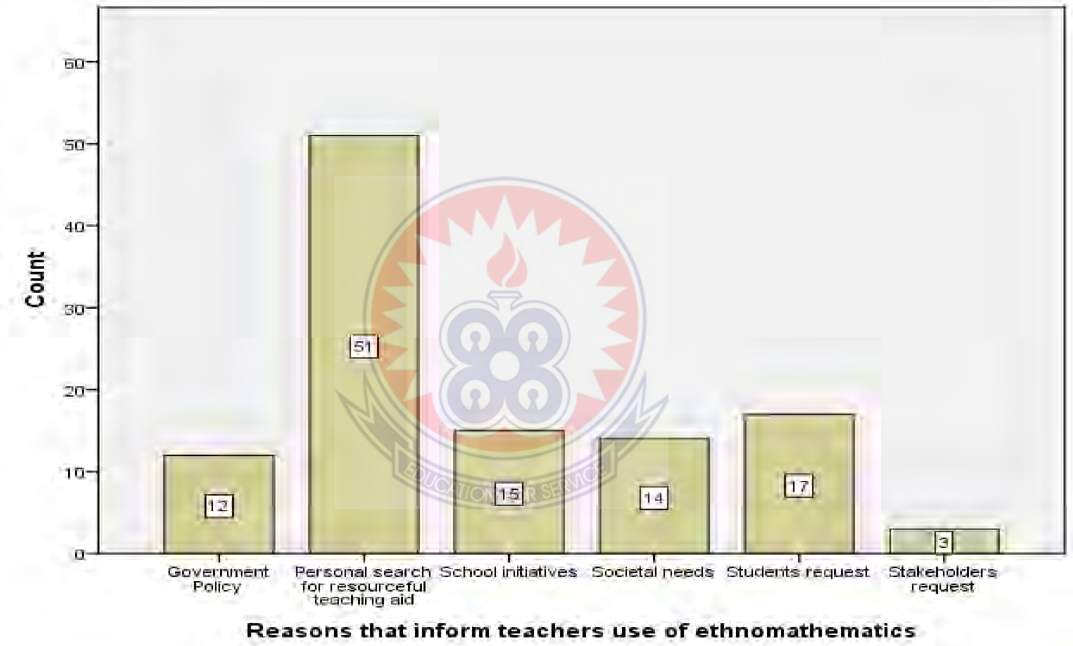


Figure 4.37: Reasons that inform teachers use of ethnoathematics

The Figure 4.37 shows a simple bar graph output from the SPSS specifying reasons why teachers use ethnomathematics approach in teaching mathematics. Majority of the respondent teachers agreed on their personal search for resourceful teaching aids among other reasons such as influence by Government policy, students request, school initiatives, societal needs and stakeholders request respectively.

There is stimulus and response association between ethnomathematics integration in pedagogical development from teachers‟ perceptual disposition. This confirms various researchers position on the need to consider ethnomathematics integration in mathematics lesson through pedagogical development on the bases of what culture suggest (Favilli, 2000; Fouze & Amit, 2018; Sunzuma & Maharaj, 2019a; Zhang & Zhang, 2010)

Table 4.42 gives the nature of students perception of ethnomathematics integration in the teaching and learning of school mathematics.

Table 4.42: Students Perception of ethnomathematics integration in Teaching and Learning

		Frequency	Percent	Valid Percent	Cum. Percent
Nature of Students Perception of the use of ethnomathematics Approach					
Response	Not all	72	64.3	64.3	64.3
	No	6	5.4	5.4	69.6
	Not sure	29	25.9	25.9	95.5
	Sometimes	5	4.5	4.5	100.0
	Total	112	100	100.0	
Whether Students appreciate teachers use of ethnomath Approach					
Response	Not at all	3	2.7	2.7	2.7
	No	5	4.5	4.5	7.1
	Not sure	11	9.8	9.8	17.0
	Sometimes	62	55.4	55.4	72.3
	Yes	31	27.7	27.7	100.0
	TOTALS	112	100	100	
Whether students enjoy the exposure to their cultural-know-how in Mathematics					
Response	Not at all	4	3.6	3.6	3.6
	No	20	17.9	17.9	21.4
	Not sure	40	35.7	35.7	57.1
	Sometimes	48	42.9	42.9	100.0
	Yes	4	3.6	3.6	3.6
	TOTALS	112	100	100	

Source: field data 2020

The study also continued to investigate into students" perception of ethnomathematics integration in the teaching and learning process. The study investigated into the nature of students" perception on ethnomathematics approach in its curriculum integration in the first segment of Table 4.42. Table 4.42 shows respondent teachers" view on the nature of students" perception on the bases of positivity. The response of „sometimes" representing 5 (4.5%), „no" response was 6 (5.4%), and „not at all" represents 72 (64.3%). On whether students appreciate teachers use of ethnomathematics approach in teaching, there is a modal response of „sometimes" representing 62 (55.4%), „yes" response were 31 (27.7%), and „not at all" represents 3 (2.7%). We probe further to find out whether students enjoy the exposure to their cultural know-how in mathematics. Respondents" view frequency were; „not at all" were 4 (63.6%), no 20 (17.9%), not sure 40 (35.7%), sometimes 48 (42.9%) and yes 4 (3.6%).

Students appreciate teachers pedagogical development of lesson and learn meaningfully if mathematical content is linked to the child familiar concept already formed (Rosa & Orey, 2019). From the constructivist theory, we expect meaningful learning to occur within the learners zone of proximal development (Vygosky, 1978). The cognitive, physical and social effect of the leaner would determine his or her current ability in the mathematical concept learned from informal and formal positions. The schools of thought of both Dewey (1916) and Vygotsky (1978) support the constructivist view of education, which states that learning is socially constructed, in which the learner is the key actor (Dewey, 2013)(Ornstein & Hunkins, 2017).

Cultural variables are themselves socially constructed and conforms to the constructivist theory on adaptive learning. Integration of ethnomathematics approach holds positive by the principal stakeholders of the teaching and learning process (teachers and students) and support the constructivist theory of adaptive learning (Smith, 1992; Volmink, 1990). Table 4.43 gives mathematics teachers response to the extent to which they agree or disagree to awareness of some policies surrounding ethnomathematics implication to teaching by respecting the learner‟s cultural identity (NaCCA, 20219).

Table 4.43: Unawareness of Policy on the Use of Ethnomathematics Approach

	Str. Disagree	Disagree	Not sure	Agree	Strongly agree
There is no influence on Ethnomathematics Approach inclusivity in Curriculum development and implementation process	2(1.8%)	1 (0.9%)	44(39.3%)	62(55.4%)	3 (2.7%)
Ethnomathematics is not considered in mathematics curriculum development	2(1.8%)	19 (17.0%)	38(33.9%)	39 (34.8%)	14 (12.5%)
Ethnomathematics is not greatly considered in curriculum implementation	1 (0.9%)	18 (16.1%)	36 (32.1%)	45(40.2%)	12(10.7%)
Teachers‟ choice of pedagogy is not culturally bounded	3(2.7%)	13 (11.6%)	55 (49.1%)	37(33.0%)	4 (3.6%)
TOTALS	112 (100%)	112 (100%)	112 (100%)	112 (100%)	112 (100%)

Source: field survey 2020

Table 4.43 presents respondents view on their unawareness of the ethnomathematics integration in the curriculum implementation process in Ghana. Among other things, Table 4.43 looked at the following problems associated with ethnomath recognition in the math curriculum implementation process: (1) there is no influence on Ethnomathematics Approach inclusivity in Curriculum development and implementation process (2) ethnomathematics is not considered in mathematics curriculum development (3) ethnomathematics is not greatly considered in curriculum implementation (4) teachers‟ choice of pedagogy is not culturally bounded.

From the analyses, teachers view on the need to consider ethnomath in curriculum implementation process or perhaps revitalize in campaign and education of teachers on its use is of high support. On whether there is no inclusivity in the curriculum implementation, 3 (3.7%) disagreed whilst 65 (58.1%) agreed, 44 (39.3%) were not sure of it. On whether ethnomathematics is not greatly considered in curriculum development process, teachers who disagreed were 21 (18.8%), those who agreed were 53 (47.3%), and 38 (33.9%) were not sure. A similar response is given in segment three and four of Table 4.43 respectively. Majority agreed to the various responses of whether ethnomathematics is not greatly considered in curriculum implementation process and whether teachers‟ choice of pedagogical development is not culturally bounded.

On whether teachers‟ choice of pedagogical development is not culturally bounded, 16 (14.28%) disagreed whiles 41 (36.7%) agreed. 55 representing 49.1% were not sure and hence, were neutral in their response.

In conclusion, many of the respondents‟ teachers are unaware of existing policy on the need for cultural significance (ethnomathematics integration in the mathematics curriculum implementation process). There are quite a number of problems associated with the consideration of ethnomath integration in the teaching pedagogy. Unlike Indonesia where ethnomathematics philosophy is highly recognized and supported to be the integral part of every mathematics teacher‟s philosophy of teaching (Baikuni, 2018) many mathematics teachers see it otherwise.

4.9 Chapter summary

This chapter was devoted to the analyses and interpretation of data collected from various field surveys. The study uses exploratory data collection and analyses of Akan ethnomathematics concepts and activities. The study investigated through a qualitative analysis of Akan ethnomathematics concepts in Akan communities that support the teaching and learning of school-based (formal) mathematical concepts in Ghanaian curriculum implementations. The study further investigated through quantitative analyses, the response of teachers and students on their view of the use of ethnomath approach of teaching and its effect on the teaching and learning of mathematics in the formal school system. The analyses were done by focusing on the formal and informal position of ethnomathematics versus formal mathematical concepts existing in Akan communities in the chosen locality and school selected for this study. We followed the analyses and interpretation of results findings based on the level of conceptual framework as well as theoretical framework defined for this study.

The results analyses and interpretations are based on the study"s research objectives and questions stated in chapter one. Mixed exploratory methodology approach was used for the analyses where both qualitative and quantitative were explored respectively. The fragment of the chapter was aligned to give analyses and interpretation of the data from the field of observations, interviews and photographs. The study took into consideration the informal Akan ethnomathematics that supports the teaching of some of the mathematical concept in the formal structure. The section further investigated focus group opinion on their knowledge of ethnomathematical applications to the products they make or sell. The study demonstrated in addition, the methodological implication of Akan ethnomathematics and their implication to teaching through Realistic Mathematics Education (RME) ethnomathematics approach.

The data collected (scores of students) from experimental lessons helped in investigation of the effect of ethnomath approach of teaching on students" academic achievement, effectiveness and usefulness of its integration as well as the interest and motivation associated with it usage.

CHAPTER FIVE

SUMMARY, CONCLUSSIONS AND RECOMMENDATIONS

5.0 Overview:

This chapter presents summary of the thesis report by looking at the major and minor findings of the study"s investigation. This summary considers the general purpose of the study, the chosen methodology as well as results from the findings of the study. The chapter discusses the resulting conclusions based on the acumens discussed from the data analyses. Evidences deduced from the analyses enlightened the need to give recommendations best for development in teaching, resource-based teaching, curriculum development as well as possible areas for further research studies within ethnomathematics framework, especially from Ghanaian perspective.

5.1 Summary

The study sought to investigate ethnomathematical construct and concepts inherent among Akan socio-cultural activities that affect mathematics teachers" pedagogical actions in the curriculum implementation process. The purpose of the study was to investigate ethnomathematics concepts in the Akan communities that support the teaching and learning of mathematics and to investigate the effect of ethnomathematics on students" interest and achievement in studying mathematics as well as teachers" perception of ethnomathematics approach in teaching. We demonstrated ethnomathematics approach practically in a demonstrational school to further investigate it effect on students" interest and perception of its integration in the teaching and learning process. The study was guided by the following research the objectives:

1. To explore basic Akan ethnomathematical activities that can support the teaching and learning of school mathematical concepts.
2. To find out how Akan Ethnomathematics (informal) connect School-based curriculum mathematics (formal) teaching and learning.
3. To investigate any effect of ethnomathematics integration to teaching formal school mathematics on students‟ achievement in studying mathematical concepts.
4. To explore teachers‟ and students‟ perceptions of the effectiveness and usefulness of ethnomathematics integration in teaching and learning of school mathematics
5. To investigate the effect of ethnomathematics integration to teaching mathematics on students‟ interest and motivation in studying selected topics in Ghanaian core mathematics curriculum.
6. To investigate problems and challenges associated with the ethnomathematics integration in the teaching and learning of school mathematics.

An explorative mixed research design was adopted for the study where both qualitative and quantitative methods were considered. The study considered a field survey of Akan ethnomathematics through their language systems in number recognition where number and numeration were considered to have place-value of base ten. Their artifacts which possess ethnomathematics were looked at on the ethnomath base of what they wear, what they use for cooking, buildings and among other 3-dimensional artifacts such as those illustrating circles and conics, mensuration and geometry.

Their social interaction possessing ethnomathematics such as games were explored too. Their technological base of ethnomathematics were investigated trough indigenous traditional engineering and technology that lead to their artefact‟s creations. A lot exist in the form of culture and geometry of which many researchers have talked about in similar communities in Africa. This is not different from Akans in Ghana in terms of mathematical applications to indigenous technology such as *kente* weaving industry, building backyard fencing, fishing nets and *agyokuo*, among others. Gesture illustrations of Akan ethnomathematics was surveyed from traditions and cultural way of representing them to deduce informal mathematical concepts that could be adopted into the formal illustrations. Such gestures include the figure counting techniques using hand and feet, stroke and tallying, etc.

The study made connections to the formal way of teachers‟ illustrations in the classroom based on Akan ethnomathematics. Other form of Akan ethnomathematics such as illustrative folktales could be rebranded to teach word problem solving and other algebraic concepts. Some recreational ethnomathematics exist in Akan communities in the form of riddles and puzzles as a sub-class of training the intuitive mind of the people and exploring nature, based on cognitive knowledge search and exploration. There exist other forms of Akan ethnomathematics to represent mathematical concepts such as fractions, percentages, distances, measurement of length and distance, measurement of area and perimeter, measurement of time. Other geometrical exploration of mathematical concepts were surveyed such as properties of rectangles, parallelogram, rhombus, squares based on parallel lines, concepts of similarity and congruence, and measurement of area with application to farming through mounds making, acre and hectare measurement and among other mathematical concepts of measurement.

The study made a link to the nature of formal mathematics syllabus and the seven (7) broad conceptual areas to be considered. A link was made to reconcile the Akan informal mathematical concepts to the most formal so as to consider resource-based learning through Realistic Mathematics Education (RME). A situation where mathematics is made real, concrete and non-abstract. Familiarity of mathematical concepts to children make them understand the abstractions and generalization inherent in the formal mathematics teaching.

The study considered the explorative mixed design methodology through the scientific research survey. A situation which demand that, qualitative is not telling the entire story of the findings and hence demands further exploration into quantitative survey to build up clearer evident based findings. This gave the opportunity for the analyses to be done through qualitative and quantitative analyses. Principally, research question one from objective one considered an in-depth qualitative data analysis from guided interviews, observations, archival record and photographs. The researcher took the opportunity to move through Akan communities where existing evidences are there to support the ethnographic survey where tradition and culture speaks mathematics before idealization of formal mathematics concept, (the whitish mathematics or Eurocentric form of mathematics).

The study considered the major target population to be mathematics teachers in Ghana of which the accessible population was Techiman municipal with its suburb and adjunct (Techiman North and South) respectively. This constituted a census sampling of mathematics teachers in the twelve (12) Senior High School (SHS) within its clustered environs. In all 112 teachers were surveyed for their views on ethnomathematics approach of teaching mathematics as well as 86 students used for a follow-up experimental lesson on ethnomathematics approach of teaching. Their perceptual disposition as well as their perception of it integration into the formal curriculum implementation process were looked at. This made it possible for us to analyse research questions two to five respectively. A supporting analysis was done from a pilot teaching of the ethnomathematics approach as a demonstrational lesson in Techiman SHS for some adopted classes. Students‟ scores from pre and post intervention teaching and assessment formed the bases for supporting analyses to this research. In order to investigate the impact of ethnomathematics approach (pedagogical moves) in the teaching and learning process, teaching pedagogy was design from ethnomathematics to teach selected mathematical concepts from the Ghanaian SHS core mathematics. One demonstrational school was selected from Akan native community, Techiman Senior High School (SHS) in the Bono East region of Ghana. The school was seeded control group (who were taught the normal conventional methods of teaching secondary mathematics) and experimental group (who were taught with various ethnomathematics pedagogical moves). Teachers of the same qualification were given a thorough training to assist in the teaching of these concepts. Students were assessed and reacted to questionnaire. Their response served as part of data collection used for the analyses in chapter four.

Analyses was done based on thematic consideration to the last four (4) research questions defined for this study: (2) What is the effect of ethnomathematics approach to teaching mathematics on students‟ interest and motivation in studying selected topics in Ghanaian core mathematics curriculum? (3) What is the effect of ethnomathematics approach to teaching mathematics on students‟ achievement in studying selected topics in Ghanaian core mathematics curriculum? (4) What are mathematics teachers‟ perceptions on the integration of ethnomathematics into teaching SHS mathematics? (5) What are students‟ perceptions on the integration of ethnomathematics into teaching

SHS mathematics? These demanded a quantitative analysis for the collected data from both teachers and students within the study delimited geographical location.

Analyses of these was based on mathematics educators from the selected schools. The implementation of the core mathematics syllabus is the mandate of every SHS mathematics tutor. Mathematics educators have placed learners in the centre of learning atmosphere to interact with several factors that would help support meaningful ways to bring a meaningful understanding of mathematical concepts taught to the learners as prescribed by the curriculum. Teachers knowledge and perception of ethnomathematics approach in teaching are sought for and analyzed accordingly. Their views on this naturalistic approach of teaching by looking at cultural dynamics that are deemed to inform mathematics educators on how the curriculum is implemented to support learners‟ cultural dictates from informal perspective in some part of Ghana.

The study used several designs to assist the chosen methods of data gathering and analyses. Following the ethnographic approach used for the study‟s first objective was the Quasi-experimental design along the magnitude of quantitative data analyses for the observed scores of students‟ assessments after the lessons was considered for the rest of the objectives. Various descriptive and inferential statistical analyses were done to investigate whether significant mean difference exist among the treatment schools and groups. The significant mean difference for two populations (control and experimental) was done under the assumption of Standard z-test statistics. We explored descriptive statistics on every response given in the questionnaires and interview. In all, there were forty (40) questionnaires considered for the analyses. The output of the descriptive and inferential statistics was done using the SPSS, Minitab, STATA, Intellectus Statistics and the MS excel based on various complexities and character qualities of the analyses, designs and outputs best fitting the analyses and discussions.

Below are the findings of the study.

5.2 Findings

The study revealed findings surrounding the research questions and objectives stated for this study. After the analysis of the responses from qualitative and quantitative data, we outline below the various findings for this study.

The investigation to the first research question "Basic ethnomathematical activities in Akan communities that can support the teaching and learning of school mathematical concepts". The Akan ethnomathematics is seen in various traditions and culture of the people. This existed since time immemorial. Cultural elements in various dynamics was seen supporting ethnomathematics in some informal illustrations transmitted through oral tradition. These cultural dynamics was organized into five main themes based on the standards in mathematics under the new syllabus four strands; number, algebra, geometry and measurement and data. Among these strands in ethnomathematics are those that support the teaching and learning of numbers, algebra, geometry and measurement as well as data. The ethnomathematics activities supporting the teaching and learning of number and numerations, number operations, fractions percentages, ratio and proportions were done through oral communication in various counting and sharing techniques. There are other numerical language patterns, games illustrative ethnomathematics guiding their socio-entertainment and edutainments. Others included gestures that possess numbers and operations as well as artefacts from 3-dimensional forms that spell out various mathematical concepts. There exist other forms of recreational ethnomathematics existing in the form of folklores, riddles and puzzles, ethnomathematics based on ethno-technology which serves as the bases of traditional indigenous technology upon which other artefacts are engineered. In addition are other concepts of measurement such as distance, percentages, fractions and other primary mathematical concepts.

Majority of Akan ethnomathematics activities suggest and support the teaching and learning of geometry and measurement. Their mathematical know-how allows them to create various activities in various shapes and space, constructed with clear area, volume and perimeter distinctions for peculiar purposes. These can serve as resource base in the teaching and learning of mensuration, geometry and measurement in the curriculum implementation of the formal syllabus. It is observed that there is no written record of Akan concept of number and numerations and the mathematical skills used in their ethno-technology. Such mathematical ideas and conceptualization were transmitted through oral tradition before they were enlightening into formal education systems. The Akan numeration and counting system possess base ten place value concept. For example, *edu* (tens) *ɔha* (hundredths) *Apem* (thousandths) and the *ɔpe* standing for the uniqueness of a million representation. Some respondents misuse it and say *ɔpe* (*ɔpe*-*pe-pe*) to represent billion connotations. The Akan ethnomathematics is richer in various number generic representations to illustrate fractions, ratio and proportions termed as *nkyekyemu*.

Games and artifacts are on the doorsteps of every Akan child. They craft and play with them with certain mathematical concepts. Making it part of the curriculum would build their self-esteem in their cultural identity. The mathematics teaching would be meaningful when explored further in curriculum implementation process. Traditional focus group who create various artifacts is believed to have mathematics ideas. For example, the survey of Akan artefacts such as *kente* weaving, kitchen artifacts such as *apɔtɔyoa* (earth-bowl-ware), *suhina* (barrels) etc. possess the concepts of pi (π) explicitly with a closed margin of 3.142. Geometrical area measurement was seen in their farming techniques such as mounding rows and Colum wise counting, plot surveying by foot-counting and fathom techniques and among others. The concept of sets is referred to as *akuokuo.* It is believed that, things could be grouped into groups and groupings based on similarities implied by the objects. This application is seen typically in Akan communities in market transactions where items for sales are grouped into similar items showing set representations.

The Key content and mathematical construct/concepts illustrated by the dame and oware games has long been used as an intuitive method of conserving number and numerations concepts. They possess the ability to recognize numbers, conceive natural counting in base four (since the marbles must be started and won on the bases of four counts) and among other number pattern concepts. Akan Geometric-Based Game illustrations apply permutation and combination in circular arrangement and selections-Gradual exposal of individuals to this dame game would help enrich their experience in life decisions, critical thinking skills, decision making process, train the youth for war tactics, how to read the minds of other and enrich their understanding of permutation and combinations. The games can be used to teach data handling and probability.

Gestures illustrative of Akan ethnomathematics. Akan ethnomathematics can take other different forms such as their gestures and mannerism used to communicate and express themselves in mathematical concepts. Some of these gestures include figure counting techniques, foot-counting, arm stretching for arbitral measurement techniques, fathoms and among others. The findings also revealed that indeed several connections exist between the informal positions of Africanists ethnomathematical concepts to the adapted formal curriculum for the main mathematical standards, strands and sub-strands respectively for the areas in which the new core mathematics syllabi focuses.

The study revealed a comparative significant mean difference for experimental classes between pre-test and post-test scores of students who were exposed to the practical ethnomathematics lessons. These lessons were demonstrated in the formal setting of the curriculum implementation using the ethnomathematics approach of teaching and learning. There was an average impact of 21.48% of the experimented ethnomathematics approach in the learning outcomes of students. This was evident in the performance analyses for the combine mean difference tested to be significant under the studentized t-test distribution.

In research question three, the effect of ethnomathematics approach in teaching mathematics on students‟ interest and motivation to study the selected formal mathematics concepts was significantly positive. Teachers and students view on motivation associated with ethnomathematics approach was rated with a mean of 3.01 and 4.71 respectively on the Likert scale between 0-5. However, majority of the sample teachers comprising 75% were not aware of the ethnomathematics approach and it suggestive application to the curriculum implementation.

Research question four sought to investigate further teachers and students‟ perception on the effectiveness of the ethnomath integration in the teaching and learning process of school mathematics. The perceived usefulness was rated mean scale of 4.03. The positive perception had a mean ration of 3.9 whiles the negative perception of the approach was 1.9. A further qualitative interview analyses was done to reveal interestingly positive perception of the ethnomath approach by both teachers and students.

Research question five further explored mathematics teachers and students‟ perception on the usefulness of ethnomath integration in the teaching and learning of school mathematics. Teachers and student Likert ranked scale average perception of usefulness of ethnomath approach in learning yielded 3.68 and 3.74 respectively. A similar perception with respect to usefulness to teaching resulted in 4.57 and 4.4 respectively. Hence the usefulness of ethnomath approach to teaching and learning is worthwhile and needs to be considered in the curriculum implementation process.

The implication to the ethnomath approach to the teaching and learning relative to socio-educational theories is that students" mathematical thinking improves whenever they are exposed to teaching that links their priori knowledge from their environment and culture. This is in consolidation to the constructivist theory such that the ethnomath approach put students in their "*Zone of Proximal Development*, (ZPD). The work of *sociocultural theory* is to explain how individual mental functioning is related to cultural, institutional, and historical implications. It is a fundamentally new approach to the problem that learning should be matched in some manner with the child's level of development. The theory constitutes a transmission meanings model on „*the participation model of cultural development*". This allows students to participate in the teaching and learning well, since the methodological and pedagogical approach appeals to their cognitive familiarity and builds their cultural heritage.

5.3 Conclusions

The Akan ethnomathematics is seen in various traditions and culture of the people. This existed since time immemorial. Akan ethnomathematics exist in different forms. It is evident that Akan language forms possess a rich number and numeracy called *nkontabude*Ɛ as their language describes. The Akan ethnomathematics activities support the new and old syllabus mathematical themes, areas and strands in the form of number, algebra, geometry and measurement, data mensuration and others. Evidence from discussions and analyses of students obtained scores from all experimental treatment classes revealed an improvement of ethnomathematics approach (pedagogical moves) used to teach mathematical concepts. This helps brings meaningful teaching and understanding of mathematical concepts. A common mean differennce existed within the mean scale for selected experimental treatment groups. This difference is created as a result of the impact of ethnomathematics moves, best suiting the cultural setting of the people in the community from which students from this background are hosted.

There is a great impact of the ethnomathematics approach (moves) in the teaching and learning of mathematics on teachers teaching and student academic achievement. The cultural diversity engrossed every individual and our full participation is certain (Barton, 1996; Ambrosio, 2001; Friansah & Yanto, 2020; Orey & Rosa, 2007; Rosa & Orey, 2017). Ethnomathematics as a branch of mathematics philosophy, (D"Ambrosio, 1987) is experimented in pedagogical development of mathematics curriculum implementation to have positive impact on the teaching and learning of mathematics. Children live and grow with culture and hence this help them to build basis of their intuition and understanding. We cannot ignore such fountain of knowledge (ethnomathematics) serving as Relevant Previous Knowledge (RPK) for any formal teaching and learning.

There are quite a number of cultural dynamics from Akan multicultural settings that really support curriculum implementation in mathematics. The mathematical educational systems could be supported by pedagogical approaches that adapt ethnomathematics methodologies suggested by the learners" environment, culture and materialistic tools that serve as the bases of resourceful teaching and improvisation in mathematics education. The study saw a clearer interconnection between an informal ethnomathematics ideas to the formal mathematics presumed by most researchers as Eurocentric (Frankenstein & Powell, 1997; Gerdes, 1997). The design of the Ghanaian mathematics curriculum from all levels has no suggestive measures to teachers" choice of ethnomathematics approach in the teaching and learning process. This has created little awareness of ethnomathematics to most teachers. The broad structure and scope of the mathematics curriculum have a close connection to the informal knowledge based on many traditional and socio-cultural dynamics. These cultural dynamics possess ethnomathematics the children grow up with which support the content-based structure of the subject they are taught.

Few challenges were observed to impede teachers choice of ethnomathematics integration to teaching formal mathematics. Both teachers and students observed that, ethnomathematics approach and integration into the formal teaching and learning process impede the speed level of covering the syllabus early. It slows the lesson. Despite the observed challenges and problems associated with it, students interest was however observed to be significantly positive.

Ethnomathematics approach in teaching mathematics affect students‟ interest and motivation to study the subject. Motivation and interest in doing something becomes effective if stimulus and response is fulfilled well. Students appreciated the ethnomath lesson and proportionately develop interest in studying the lessons. The end results is undoubtedly fruitful understanding of whatever was learnt. Hence students‟ academic achievement is boosted when their motivational and interest level in studying the subject is meaningful. This is in consolidation to what (Fouze & Amit, 2018; Higgins & Huscroft-D‟Angelo, 2019; Uloko & Usman, 2008) found out on the driven force ethnomath There is stimulus and response association between ethnomathematics integration in pedagogical development of teachers‟ lessons. This confirms various researchers position on the need to consider ethnomathematics integration in mathematics lesson through pedagogical development on the bases of what culture suggest (Favilli, 2000; Fouze & Amit, 2018; Fouze & Amit, 2018a; Sunzuma &

Maharaj, 2019; Zhang & Zhang, 2010). Cultural variables are themselves socially constructed and conforms to the constructivist theory on adaptive learning. Integration of ethnomathematics approach holds positive by the principal stakeholders of the teaching and learning process (teachers and students) and support the constructivist theory of adaptive learning (Smith, 1992; Volmink, 1990) bounded by students zeal to study.

The perception teachers and students have on the effectiveness of the ethnomathematics integration in the teaching and learning process of school mathematics is positively directed. It is perceived by both teachers and learners (who are the forefront stakeholders of the heat of teaching and learning) that ethnomathematics approach of teaching ensures effective learning and students‟ academic achievement. This is in support to research evidence by, (Achor et al., 2009; Nyengera, 2016; Orim & Uzoma, 2019) on how ethnomathematics has become effective teaching pedagogy in the current trend of mathematics education.

In addition, Ethnomathematics has become one of the most useful teaching tool to facilitate mathematics educators‟ pedagogical skills. Mathematics teachers and students‟ perception on the usefulness of ethnomath integration in the teaching and learning of school mathematics is positively directed. Hence the usefulness of ethnomath approach to teaching and learning is worthwhile and needs to be considered in the curriculum implementation process.

Ethnomathematics help build students‟ mathematical thinking. Their cognitive and mathematical intuition improve whenever they are exposed to teaching, that links their priori knowledge from their environment and culture. This is in consolidation of what the constructivist theory suggests when the ethnomath approach put students in their "Zone of Proximal Development, (ZPD)" (Smith, 1992; Volmink, 1990;

Wilkinson & Shank, 2019). Evidence here is confirmed by (Teye, Tetteh, et al., 2018) as he sees cultural effect of students learning and critical thinking skill from their adaptive environment. The work of *sociocultural theory* is to explain how individual mental functioning is related to cultural, institutional, and historical implications as a fundamentally new approach to the problem that learning should be matched in some manner with the child's level of development. The theory constitutes a transmission meanings model on „*the participation model of cultural development*‟ (Scott & Palincsar, 2018). The experimented teaching approach of ethnomathematics yielded an application of Realistic Mathematics Education (Azmi & Wardono, 2018; Peni, 2019; Purwanti & Waluya, 2019) on the bases of ethnomath principles to enhance interest in the acquisition of mathematical conceptual understanding.

5.4 Recommendations

From the findings of this study, it is recommended of the following to major stakeholders of education such as teachers, students, curriculum developers, and the community as well as future researchers in this field of study.

1. The study found a significant effect of ethnomathematics integration to teaching school mathematics on students‟ academic achievement. Hence, mathematics educators (teachers) should consider ethnomathematical philosophy of teaching mathematics and integrate them into the school curriculum implementation. The ethnomathematics approach in teaching the selected topics in mathematics proved to significantly improve students‟ academic achievement. Their level of performance improves significantly. This study suggests to mathematics teachers to be aware of ethnomathematics principles of teaching to variate their resourceful teaching.

2. The study from its field exploration of Ghanaian basic ethnomathematics found an explicit implication of ethnomathematics theory, ethnomathematics trivium (literacy, matheracy and technoray) as well as Realistic Mathematics Education (RME) principles to teaching and learning of school mathematical concepts. Mathematics educators need to understand the essence of ethnomathematics as a form of naturalistic approach in which mathematics pedagogies could be adopted. There must be a collective embracement of this new trend of teaching as a means to enriching culture by implementing the curriculum along ethnomathematical viewpoint. Teachers should make the teaching of mathematics very practical with ethnomathematics. They should prepare well with such improvisation before going to teach.
3. The study also recommends authors of mathematics books to consider exemplifying mathematics problem structure to connote ethnomathematics of the communities in which the school is situated.
4. Students should not undermine ethnomathematics approach of teaching if teachers adopt this. It has been found that students‟ interest and motivation is enhanced with this approach of teaching. This makes lessons friendly with learners and links it to their relevant previous knowledge which conform to educational axioms of teaching.
5. Curriculum developers such as NaCCA and CRDD of Ghanaian MOE should consider ethnomathematics theoretical framework and suggest for teachers to use as part of their teaching approach. The new syllabus suggest among core competence to be noted by teachers the ***Cultural Identity and Global Citizenship (CG),*** (MOE, 2020). Much needs to be suggested to teachers on

ways to integrate ethnomathematics approach to bring a common front for the cultural identity.

6. It is recommended for the alertness and inclusion of ethnomathematics into the curriculum implementation of Pre-service teachers in the colleges of education in Ghana. These teachers are under training to go and teach school mathematics. They need to be trained on the essence of ethnomathematics integration into the formal teaching of school mathematics.
7. In-service training needs to be given to field teachers and college of education teachers on the need to consider ethnomathematics integration to formal teaching of mathematics

All these would enhance the teaching and learning of mathematics and help build students interest and motivation to learn the subject.

5.5 Areas for Further Research

Based on the outlined limitations, this study becomes a useful baseline study for future research in the Ghanaian setting in the Ethnomathematics and curriculum implementation areas.

1. The study recommends further research into other areas of Ghanaian communities to find out whether ethnomathematics pedagogical approach in teaching mathematics will prove worthwhile as done to Akan ethnomath.
2. Ethnomathematics, which has mathematical implication to culture needs to be extended to other multicultural settings in all Ghanaian communities. This would build our perceptual understanding, usefulness and effectiveness of the ethnomathematics and its implication to mathematics education in Ghana.

5.6 Limitations of the study

The results and findings of this research study could not be generalized due to the following reasons:

1. There are quite a number of cultural diversities in Ghanaian multicultural systems which one way or the other, differs in believes and practices best known to the tribes and ethnic groups. Only a small section of the Akan people in the Bono East region was considered. Even though they share common cultural practices and ethnomathematical concepts with other neighbouring tribes, their settings and community schools and staff opinions were the bases of this study. Hence, the study is limited to the opinions of mathematics educators in Techiman North, South and Municipal as well as students of Techiman SHS.
2. The Akan ethnomathematics has similar findings with other Akan tribal communities surveyed by several African authors reviewed in literature, (Bannister, Davis, Mutegi, & Thompson, 2017; Nabie, Akayuure, Ibrahim-Bariham, & Sofo, 2018). It is believed that similar findings could be attributed to other multicultural settings in the Northern, middle and southern belt of Ghana tribal cultures. We should be however cautious not to conclude findings of the case study to the generalizability of the entire Ghanaian communities and schools. Despite the use of common curriculum structure universally accepted in Ghana by MOE, NaCCA, the principle of cultural implications is quite different. The study however throws recommendations on how mathematics educators in these communities can adapt an application of their ethnomath principles in guiding their pedagogies and methodological approaches in handling curriculum implementation process. There is no need to give an unhealthy comparison and

criticism on the differences in other cultural context from that of the Akan context explored.

3. The Akan ethnomathematics has no written records to reconcile with formal education systems. It is on this bases that the study terms Akan ethnomathematics as "*informal*" to dissociate it from Ghanaian MOE mathematics curriculum implementations as "*formal*". Due to this, there was the need to always compare the mathematical concepts and construct from these two perspectives. The intention was to survey a qualitative analyses of Akan non-formal mathematics principles called the ethnomathematics to find out the mathematical concepts and knowledge base in the hidden of culture. There was a followed-up with an experimental lesson to operationalize the existing theories on ethnomathematics (Forbe, 2018) making the study an exploratory mixed design method. This study however implores readers that there are cultural terms usage from the Akan dialects which have been duly explained, the best of its formal interpretation in the contextual connotation in this study.
4. There is little literature on ethnomathematics from Ghanaian multicultural context. Akan people have a lot of culture (from socio-cultural, religious-culture, politico-cultural and among others). Only few cultural elements and dynamics were explored. A review of this study dealt with selected Akan cultures that are deemed to support the teaching and learning of mathematical concepts only.

5.7 Chapter Summary

This Chapter discussed the summary of the entire thesis and gave discussion of findings (both major and minor findings) as well as the resulting conclusions based on the findings. It further gave limitations and suggested some recommendations for teachers, learners, curriculum developers and future researchers.

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APPENDIX A

LETTER OF CONSENT TO STUDY PARTICIPANTS

I take the opportunity to welcome all of you to these series of demonstrational lessons. We hope you are going to enjoy your studies as you put in your maximum best. It is an opportunity for us all to enjoy teaching and learning in an atmosphere of socio-cultural interactions.

This lessons I am going to have with you will help us investigate into *Ethnomathematical Construct Supporting Curriculum Implementation in Ghana*. In fact we are to have second look at what mathematical concepts are hidden in the cover-sleeves of our cultural activities. Do our culture speaks mathematics? Did our great-grand- fathers" new mathematics? We seek to employ various cultural dynamics in the teaching and learning for this semester. Enjoy your lessons and don"t fell offended as we play games, do a lot of cultural surveys adopted for the sake of this investigation.

Before we begin, I would like to know your background in some of the basic concepts we are going to study by giving you a test. Results obtained will be used in a study to investigate students" conceptual knowledge of the selected topics we will revise. Consideration will be given to resulting implications according to their effect on mathematics education and recommended measures made to improve on the effectiveness of the teaching and learning of these concepts at the basic and senior high levels under ethnomathematics.

Your socio-cultural background and previous teachings on the outline topics you have is enough as a prerequisite knowledge for this test, subsequent learning and post-learning test. Since the results from this test is not going to be part of your continuous assessment, feel free to answer all questions as frankly as possible. Your participation is very important; however, you have the right to decline to participate in the study. I encourage all of you to patronage in these discussions.

If you agree to be part of this study, kindly give your consent by filling the consent form attached. Thank you for your consideration.

…………………………

Isaac Owusu-Darko (Mr.)

APPENDIX B

PARTICIPANT'S CONSENT FORM

I ……………………………… a student of …………………………………school, give my consent to be part of this study. I understand the study will involve completing questionnaire, a test and an interview. I understand that all information including my socio-demographic information and student‟s identification number will be kept confidential for the purpose of this study. I understand that these activities will not disrupt my programme and results of the test will not form part of my continuous assessment.

Signed: ……………………………………………………………….

Date: ………………………………………………………………………..

APPENDIX C

REQUEST FOR DEMONSTRATIONAL LESSONS

Valley View University, Techiman Campus
P. O. Box 183
Techiman, Bono-East.

Email: iowusudarko@vvu.edu.gh
Tel: 0204228266/0243388248

21st November, 2019.

The Head-master,
Techiman Senior High School,
P. O. Box 85
Techiman.

Dear Sir

REQUEST FOR DEMONSTRATIONAL LESSONS

I would be very grateful if you could allow me do some demonstrational lesson in your school. I am a PhD student from University of Education, Winneba (UEW). I am in my final level of the program. I intend collecting data through demonstrational survey on the topic:

> *Akan Ethnomathematics Activities: Its Effect and Interconnections to The Teaching and Learning of School Mathematics*

I have selected some schools through an adopted sampling techniques of which your school forms part. I would be very grateful if two weeks with selected days could be granted unto me to arrange some demonstration lessons on ethnomathematical techniques in teaching some selected mathematical concepts deem appropriate on the school outlined schemes.

Kindly take my request as duly academic and the privacy of any other evidence found is duly assured.

I am counting on your acceptance, assistance and cooperation in this regard.

Thank you
Yours faithfully,

……………………………………..
ISAAC OWUSU-DARKO

APPENDIX D

OBSERVATION GUIDE (UNSTRUCTURED)

1. What counting techniques are there in Akan (informal) numerations?
2. How knowledgeable are people"s recognition to Akan Adinkra symbols and its application or interconnection to school mathematical concepts recognitions
3. What do Akans use stroking for?
4. What measurement techniques are there in Akan communities that are interconnect with school mathematics on the basis of
   (i) Perimeter estimation
   (ii) Arbitrary Area
   (iii) Volume measurement
   (iv) Capacity measurement
5. What are some Akan games that can be used to guide teaching of school mathematics on the basis of
   (i) game formation,
   (ii) Rules binding the game play,
   (iii) how it is played,
   (iv) ways of winning or losing
   (v) mathematical implication
6. What role does folklore and story-telling play in mathematics problem solving (word problems)?
7. What are Akan examples of ethno-technology and its implication to school mathematics?
8. What are the names of certain Akan basic artifacts that has mathematical application to school mathematics?
9. (a) What do Akans use these artifacts for?
   (b) What are Akans conception of Algebra?
10. Do producers of these artefacts see any mathematical connections or applications to these artifacts with respect to its
    (i) Creation
    (ii) Usage
    (iii) Any other

APPENDIX E

ASSESSMENT: PRETEST FOR STUDENTS

STUDENTS PRE-TEST

ETHNO-DEMONSTRATION SCHOOL
Try Examinations : 2019/2020
REAL NUMBER SYSTEMS

CLASS.........................

STUDENT ID.....................

December, 2019 ***Answer all questions***

SECTION B (REAL NUMBER SYSTEMS)

1. List the following infinite set of numbers from $(\alpha)\ formal$ and $(\beta)\ Informal$

Q. NO	QUESTION ITEM	(α) ***formal*** listing	(β) ***Informal*** Listing	Reason for your answer
i	Even numbers less than ten			
ii	Prime numbers less than twenty			
iii	Counting numbers between 10 to 20			
Iv	Multiple of 5 less than twenty			
V	Multiple of 8 between 40 to 80			
Vi	Multiple of 10 less than 60			

2. (i) Identify four traditional indigenous games that illustrate number and numeration concepts

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(ii) Give reasons for your answer

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3. I am a set of numbers that has only two factors. The factors are always one and myself. It is difficult to determine my highest value.
   (i) Whom am I?.................................
   (ii) Reason for your answer...

4. Given that $a =$ /// $b =$ ~~////~~ $and\ c = //$

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5. show that $a + (b + c) = (a + b) + c.$

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(i) What property is this?

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(ii) Give reason your answer:

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6. .

Q. NO	QUESTION ITEM	ANSWER/RESPONSE	REASON FOR RESPONSE
	Draw a Venn diagram to represent the relationship between the members of the real number systems by taking into consideration regions of subsets		

7. How does the Akans identify the number/value 1,234,352,566,677?

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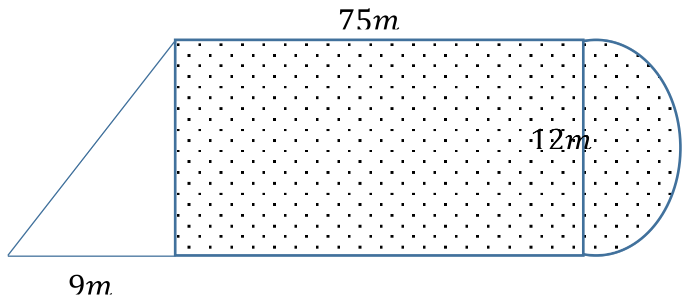
SECTION C (MENSURATION)

Evaluation: Students perform the following problem solving on mensuration

8. Agya Koo has a rectangular plot enclosed with rectangular field with triangular and semi-circular ends as shown below. Find the Perimeter and total surface area of the plot



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9. Give reason to your answer in question 7:

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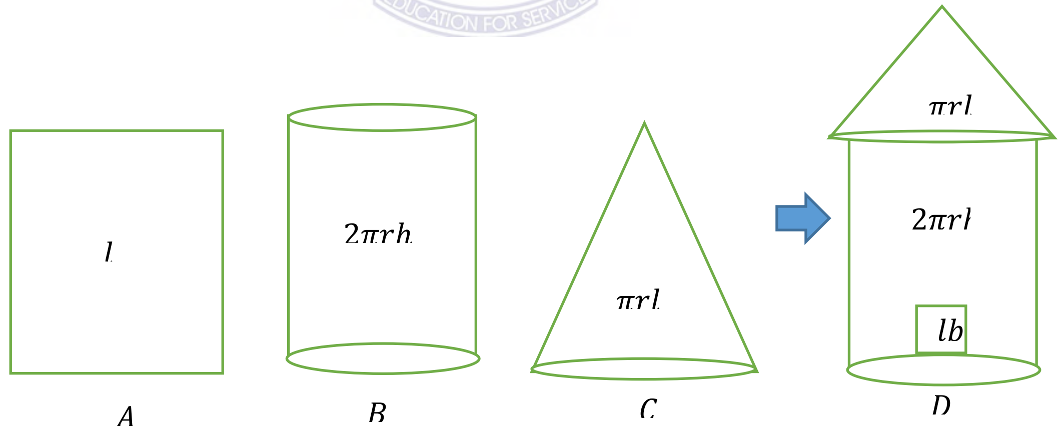
10. Given the diagram in the following specimen A-D. if the rectangle in specimen A has length (l)=15cm, width (b)=10cm and the height of cylinder is 5cm with radius 8cm whiles the conical roof in specimen C has radius 12cm with height 2.5cm respectively



11. Identify Akan artifacts from your community that have these plane geometries

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12. Find the total surface area of the building in spacemen D made out from A, B and C.

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Give reason to your answer in question 12 :

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13. Identify the geometrical shapes in the Akan Peele game

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SECTION E: (PROBABILITY AND STATISTICS TEST)

Evaluation: Students perform the following problem solving on probability and Statistics

The play of a ludo game revealed the following faces. The die was flipped 48 times and the faces resulted are shown below: (Use this information to answer questions 12-13

6	1	3	2	4	5	1	1	3	3	1	2
1	6	5	6	3	4	2	6	5	4	4	3
2	2	5	4	6	6	4	5	2	6	5	5
5	4	4	5	4	5	4	2	2	3	4	4

14. Prepare a frequency distribution table for the results and estimate the mean and standard deviation of the throw.

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15. Find the probability of observing each face.

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16. Two identical dies are rolled once, determine the sample space for this activity and find the probability that pair of the dies shows; Sum of pairs less than 10

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17. Give reason for your answer in question 17:

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SECTION F (ALGEBRA: PROBLEM SOLVING TEST)

18. We are three consecutive odd numbers, if the sum of the last two is 15 less than five times the first, who are we?

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19. A man was travelling with three (3) items namely goat, tame lion and a yam. He want to cross a bridge with a canoon that can take only one item including himself. If the canoon can pick only one items with the traveler, how can the traveler cross the river with all his items unhurt?

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20. Three men want to cross a river. They find a boat, but it is a very small boat. It will only hold 200 pounds. The men are named Okese, Honeho and Ketewa. Okese weighs 200 pounds, Honoho weights 120 pounds, and Ketewa weighs 80 pounds. How can they all get across? They might have to make several turns in the boat.

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APPENDIX F

POST-TEST ON ETHNO-DEMONSTRATION LESSONS

[GEOMETRY]

December, 2019 *Answer all questions*

SECTION B (GEOMETRY)

Evaluation: Students perform the following problem solving on plane geometry.

1. Agya Kwasi has a triangular plot enclosed by angles $67^0, and\ 53^0$. Find the third angle enclosed by his plot of land.

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2. Give reason your answer:

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3. Identify as many as geometrical shapes seen from these ethnomathematics edifices

QUESTION ITEM	ANSWER/RESPONSE	REASON FOR RESPONSE
	1. 2. 3.	
 (UNESCO, 2008)	4.	

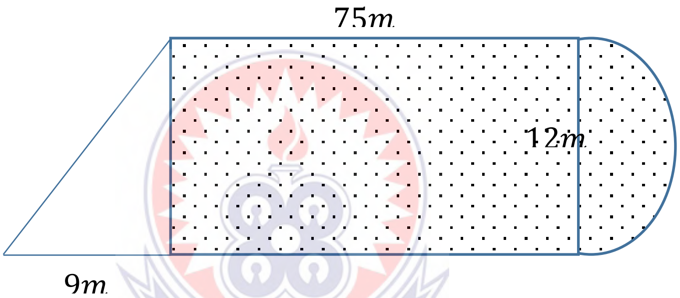
4. Identify three mathematical concepts this ethnomathematics shows in the formal curriculum

QUESTION ITEM	ANSWER/RESPONSE	REASON FOR RESPONSE
	1. 2. 3.	

SECTION C (MENSURATION)

Evaluation: Students perform the following problem solving on mensuration

5. Agya Koo has a rectangular plot enclosed with rectangular field with triangular and semi-circular ends as shown below. Find the Perimeter and total surface area of the plot



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Give reason to your answer:

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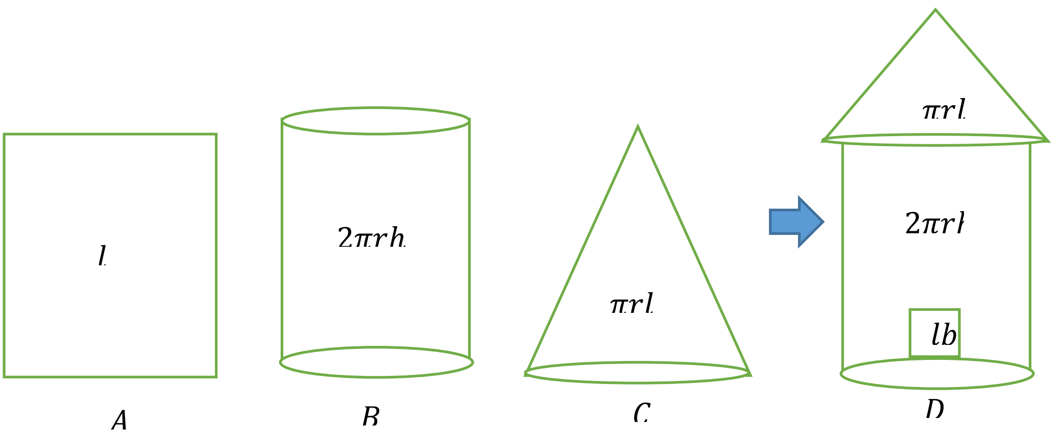
6. Given the diagram in the following specimen A-D. if the rectangle in specimen A has length (l)=15cm, width (b)=10cm and the height of cylinder is 5cm with radius 8cm whiles the conical roof in specimen C has radius 12cm with height 2.5cm respectively



7. Find the total surface area of the building in spacemen D made out from A, B and C.

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8. Give reason your answer:

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9. Estimate the volume of the building

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Give reason your answer:

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10. If painting only the external wall will cost GHS 5 per unit m, find the amount of cost the owner has to pay in the painting.

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Give reason your answer:

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11. Find the perimeter and area of your tables top, marker board, classroom using arbitrary Akan ethnomathematics measurement using hand stretching, footing and palming. Compare with the formal SI unit measurement in cm, m and km.

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SECTION E: (PROBABILITY AND STATISTICS TEST)

Evaluation: Students perform the following problem solving on plane geometry.

12. *Activity/experimental example*: Student in group play the ludo game and observe their lucks in rolling the ludo die once. Prepare a frequency distribution table for the results and estimate the mean and standard deviation of the throw. Find the probability of observing each face.

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13. Two identical dies are rolled once, determine the sample space for this activity and find the probability that pair of the dies shows; Sum of pairs less than 10

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Give reason for your answer:

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14. Prime pairs

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Give reason to your answer:

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15. Factor pairs of 12 or sums of pairs more than 10

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(iii) Give reason for your answer:

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16. Given the following probabilities $P(A) = 0.39, P(B^c) = 0.045\ and\ P(C^c) = 0.33$. Find the following probability measures: $P(AUB)$ if A and B are mutually exclusive

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(i) Give reason for your answer:

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17. The probability that Agya Kwasi finishes planting his maize before it rains is $\frac{1}{6}$ and the probability that rodents destroy it is $\frac{3}{9}$. find the probability that he plants without rains and get rodents to destroy it.

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Give reason for your answer:

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SECTION F (ALGEBRA: PROBLEM SOLVING TEST)

(i) Evaluation: Students perform the following problem solving on plane geometry.

"On Ananse‟s birthday, his grandmother cut 12 pieces of cake, after he told him that he had invited twelve friends. However, only two friends arrived on time, and the rest came later".

18. Use this to answer the following questions

Q. NO	QUESTION ITEM	ANSWER/RESPONSE	REASON FOR RESPONSE
i	If Ananse wishes to divide the 12 pieces of cake between his son Ntinkumah and himself, how many pieces of cake would each receive?		
ii	If we had 16 pieces of cake and four boys, can we divide them equally between them?		
iii	If we have six friends and 12 pieces of cake, how many pieces does each child		

19. We are three consecutive odd numbers, if the sum of the last two is 15 less than five times the first, who are we?

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20. Give reason for your answer in 19:

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APPENDIX G

(QUESTIONAIRE FOR TEACHERS)

QUESTIONAIRE TO MATHEMATICS TEACHERS

INTRODUCTION: *The purpose of this questionnaire is to investigate the effect of ethnomathematics approach in teaching mathematics (where teaching and learning of mathematics is looked at in the context of culture implications). We inquire your views on teachers" reasons of its integration in teaching as well as students" interest, motivation and achievement in mathematics education. We plead on your indulgence to help us with your views. This is for academic purposes only. Every details you provide would be treated with a true confidentiality. By admitting to consent in answering the questions, you agree to be part of the study participants. Thank you*

INSTRUCTION: ***Please tick [√] your most preferred response from spaces provided [ ]. Where applicable, you write your response to the spaces provided to an open ended question items***

SECTION A: (The use of Ethnomathematics in Teaching Mathematics in Schools)

1. Tick from the following the category that best fit you

   1. opinion leader [ ] 2. Mathematics educator [ ]
   3. Traditional leader [ ] 4. Craftman [ ]
   5. Teacher [ ] 6. Other [ ]

2. Are you aware of ethnomathematics as a philosophy in Mathematics Education (teaching of mathematics)? 1. No [ ] 2. Yes [ ] 3. Not sure [

3. Would you discourage entirely, the use of ethnomathematics approach in teaching in your Schools? No [ ] 2. Yes [ ] 3. Not sure [ ]

4. Does ethnomathematics approach in teaching interest your students?

   1. No [ ] 2. Yes [ ] 3. Not sure [ ]

5. Does ethnomathematics approach in teaching interest you as an instructor?

   1. No [ ] 2. Yes [ ] 3. Not sure [ ]

6. Would you discourage or encourage a blend of ethnomathematics in the teaching and learning of mathematics?

   Strongly discourage [ ]
   Discourage [ ]
   Encourage [ ]
   Strongly encourage [ ]

SECTION B: (Ethnomathematics and Students Mathematics Performance)

7. Do you think teachers use of Ethnomathematics in teaching and learning will improve students‟ academic performance?

   1. Not all [ ] 2. No [ ] 3. Not sure [ ] 4. Sometimes [ ] 5. Yes [ ]

8. Is ethnomathematics use in teaching subject to gender disposition?

1. Not all [ ] 2. No [ ] 3. Not sure [ ] 4. Sometimes [ ] 5. Yes [ ]

9. Does Ethnomathematics help students to learn?

   1. YES [ ] 2. NO [ ]

10. Do you support government policy on to integrate ethnomathematics in school curriculum?

1. Not all [ ] 2. No [ ] 3. Not sure [ ] 4. Unaware [ ] 5. Yes [ ]

11. Have you ever use ethnomathematics (i.e. culturally relevant resourceful teaching) to help your students learn?

1. Not all [ ] 2. No [ ] 3. Not sure [ ] 4. Sometimes [ ] 5. Yes [ ]

SECTION C: (Teachers' Perception of the usefulness and effectiveness of Ethnomath integration in Teaching school mathematics).

12. What perception do you as a mathematics teacher have on the usefulness and effectiveness of ethnomathematics integration in teaching school mathematics? (*Please tick [ ] from the extent to which you agree or disagree from the table below).*

Statement about teachers Perception on the use of ethnomathematics in teaching	Not sure	Strongly Disagree	Disagree	Agree	Strongly agree
Ethnomathematics develops mathematical thinking					
Good ethnomaths pedagogies could help students to learn math well					
Teaching mathematics in socio-cultural way would build interest in learning					
I see ethnomathematics as resourceful teaching					
Ethnomathematics involve a lot of improvisation					
It is difficult to apply ethnomathematics in classroom					

13. What is your Perceived effect of ethnomathematics integration in teaching and learning process

Average scaling of Effect	Not Sure	Strongly Agree	Disagree	Agree	Disagree
Perceived effect on the use of Ethnomathematics Approach integration on lesson planning					
Perceived Effect of Ethnomathematics Approach in Teaching Mathematical Concept					
Perceived Effect of Ethnomathematics approach on Students" Academic Achievement					
Perceived effect on the use of Ethnomathematics Approach on assessment criteria					
Perceived effect on the use of Ethnomathematics Approach on Curriculum development and implementation					

SECTION D: (Ethnomathematics versus curriculum implementation).

14. Should ethnomathematics be considered in in Curriculum development and implementation?

Students perception of teachers use of Ehnomath	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree
Ethnomathematics is greatly considered in curriculum development					
Ethnomathematics is greatly considered in curriculum implementation					
Teachers choice of pedagogy is culturally bounded					
More than 50% of teachers consider ethnomathematics pedagogy					
CRDD should consider ethnomaths greatly when developing math syllabus					
Teachers choice of ethnomath is based on improvisation					

SECTION E: Perceived effect of ethnomathematics on students' interest and motivation in mathematics

15. When is it appropriate to use Ethnomathematics in teaching mathematical concept? (*Please tick [ ] from the extent to which you agree or disagree from the table below).*

Statement Premise	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree
Teaching students math in cultural context boost their interest					
Ethnomathematics enhance teaching and learning					
To ensure students perform well					
Students are motivated intrinsically					
Students are motivated extrinsically					
Ethnomath help students to understand lesson easily					

16. When is it appropriate to use Ethnomathematics in teaching mathematical concept? (*Please tick [ ] from the extent to which you agree or disagree from the table below).*

Statement Premise	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree
As a resourceful teaching					
To enhance teaching and learning					
To ensure students perform well					
As a means to preserve culture of the people					
It is dictated by GES					
Syllabus suggest it usage					

17. what effect does ethnomathematics approach of teaching has on students" interest in learning mathematics

…………………………………………………………………………………………………
…………………………………………………………………………………………………

18. what effect does ethnomathematics approach of teaching has on students" motivation in learning mathematics

…………………………………………………………………………………………………
…………………………………………………………………………………………………

SECTION G: Problems associated with the use of Ethnomathematics Approach in teaching

19. What problems are associated with the integration of ethnomathematics in teaching school mathematics? (*Please tick [ ] from the extent to which you agree or disagree from the table below).*

	Not Sure	Str. Disagree	Disagree	Agree	Strongly agree
It retards progression of teaching					
It dulls the lesson					
Delays completion of syllabus					
Restrict students" inattentiveness					
Ethnomath integration in teaching mathematics burdens teachers					
Ethnomathematics involves a lot of improvisation					
Ethnomath approach is tedious and difficult task					
It is difficult to apply ethnomathematics in classroom					

20. Are teachers awareness of Policy on the Use of Ethnomathematics Approach in teaching school mathematics? (*Please tick [ ] from the extent to which you agree or disagree from the table below).*

Statement	Not Sure	Str. Disagree	Disagree	Agree	Strongly agree
There is no influence on Ethnomathematics Approach inclusivity in Curriculum development and implementation process					
Ethnomathematics is not considered in mathematics curriculum development					
Ethnomathematics is not greatly considered in curriculum implementation					
Teachers" choice of pedagogy is not culturally bounded					

SECTION H: Perceived effect of ethnomathematics on students' interest and motivation in mathematics

21. How often do you usually establish interconnection with these Basic ethnomath (informal mathematics) with school mathematical concept (formal mathematics) teaching? (*Please tick [ ] from the extent to which you agree or disagree from the table below).*

	Basic Ethnomathematical Activities	School mathematical concept	Used Often (%)	Use occasionally (%)	Do Not Use at all (%)
1	Adinkra symbol (*Mmere Dane, Gyenyame, Adinkrahene*)	Shape and space			
2	Stroking and tallying	Statistics, data collection and number counting			
3	Measurement of time (*mmere*)	Time, shape, space			
4	Counting and geometrical game	Number counting, numeration system, geometry			
5	Finger counting	Number counting, numeration system			
6	Naming techniques	Number counting, numeration system, sequence			
7	Hand stretching	Measurement of lines and distances, geometry			
8	Farm practices (ridging and mounding)	Measurement of area, perimeter			
9	Folktales and story telling	logical reasoning, Problem solving strategies			
10	Riddles and puzzles (recreational ethnomath)	Algebra, logical reasoning, sets			

APPENDIX H:

QUESTIONAIRE TO STUDENTS

INTRODUCTION: *The purpose of this questionnaire is to investigate the effect of ethnomathematics approach in teaching mathematics (where teaching and learning of mathematics is looked at in the context of culture implications). We inquire your views on your perception of its integration in teaching as well as students" interest, motivation and achievement in mathematics education as a result of the various experimental lessons encountered. We plead on your indulgence to help us with your views. This is for academic purposes only. Every details you provide would be treated with a true confidentiality. By admitting to consent in answering the questions, you agree to be part of the study participants. Thank you*

INSTRUCTION: ***Please tick [√] your most preferred response from spaces provided [ ]. Where applicable, you write your response to the spaces provided to an open ended question items***

SECTION A (DEMOGRAPHIC INFORMATION)

INSTRUCTIONS: *Answer all questions. Please tick [ ] or underline the response option that indicates your view or opinion on each of the given statements. Where possible provide short answers*

21. Gender: 1 Male [ ] 2 Female [ ]
22. Age: ………………………………….(in years)
23. What is your class A. Arts 2 A [.] Arts 2B [.]
24. In which region of Ghana do you come from? (Please tick)

Northern	Bono-East	Bono	Ahafo	Ashanti	Any other
1[ ]	2[ ]	3[ ]	4[ ]	5[ ]	6[ ]

25. Have you been involved in cultural activities that involve mathematics applications? 1 Yes [ ] 2 No [ ]

SECTION B (participants' view on their perceived effect and usefulness of Ethnomathematics approach in teaching mathematics)

26. What is the nature of Students perception of ethnomathematics integration in teaching and learning of mathematics lessons?

Students perception of teachers use of ethnomath	Not sure	Strongly Disagree	Disagree	Agree	Strongly Agree
Teachers normally use cultural context to explain mathematical concepts					
Ethnomathematics helped me to understand the mathematical concept in the demonstrational lesson					
I will like all mathematics teachers use ethnomathematics in teaching us					
Studying with ethnomaths makes me feel nervous					
ethnomathematics make me feel uncomfortable in class					
Ethnomaths approach in teaching made me feel I am learning at home					

SECTION C: (Participants' Perception of mathematics learning)

27. What is the nature of Students perception of Mathematics and ethnomathematics

Students perception of Mathematics learning	Not sure	Strongly Disagree	Disagree	Agree	Strongly Agree
Mathematics is one of the most important subject people should study					
Math is one of the most dreaded subject					
My mind goes blank and get confused when studying mathematics					
Studying maths makes me feel nervous					
Mathematics make me uncomfortable					
When I hear the word mathematics, I have a feeling of					

dislike					
It makes me nervous to even think of solving mathematics problem					
I am always confused in my mathematics class					
Good maths pedagogies could help me learn math well					
Teaching mathematics in socio-cultural way would build interest in learning					
My interest is built in studying mathematics					
I have a carrier to build in studying mathematics					

28. Students perceived effect of ethnomathematics approach on learning of mathematics

statement of effect	Not sure	Strongly Disagree	Disagree	Agree	Strongly Agree
Ethnomathematics help students to learn better					
Positive perceptual effect of ethnomathematics on students learning					
Negative perceptual effect of ethnomathematics on teaching and learning					

29. SECTION D: Response by ticking [✓] Yes or No to whether the following selected *Akan* Basic Ethnomath has implication to your understanding of the selected school mathematics in the demonstration lesson.

	Basic Ethnomathematical Activities	**School mathematical concept**	**Yes**	**No**
1	Adinkra symbol (*Mmere Dane, Gyenyame, Adinkrahene*)	Shape and space		
2	Stroking and tallying	Statistics, data collection and number counting		
3	Measurement of time (*mmere*)	Time, shape, space		
4	Counting and geometrical game	Number counting, numeration system, geometry		

5	Finger counting	Number counting, numeration system		
6	Naming techniques	Number counting, numeration system, sequence		
7	Hand stretching	Measurement of lines and distances, geometry		
8	Farm practices (ridging and mounding)	Measurement of area, perimeter		
9	Folktales and story telling	logical reasoning, Problem solving strategies		
10	Riddles and puzzles (recreational ethnomath)	Algebra, logical reasoning, sets		

SECTION E: Participants' recognition of interconnection between school mathematics and Akan ethnomathematics

30. Tick ( ) from the following table whether you recognize an interconnection of the selected Akan ethnomathematics with the formal school-based mathematical concepts (yes) or otherwise (no)

	Basic Akan Ethnomathematical Activities	School-based mathematics standard concepts	Yes	No
1	Number and numerations (*Nkontabudeɛ*)	Counting		
2	Measurements (*Nsatea, nsayem, basafa. Anamon, nsatremu, kwansin, kwantenten*)	Measurement of length and distance (unit and dimensions)		
3	Set ethnomath (*aboaboa, boa*)	Set, logical reason		
4	Akan Algebra connotations (*biribi-x, ebi-x/100%, nyinaa-100%, nohoaa-∞*)	Algebra concepts		
5	Geometric-based games (Peele, antoankyire, dame)	Geometry, polygons, area and perimeters		
6	Geometric-based Artefacts: earth bowls wares (apoyowa, suhina, tapoli, Ayowa)	Geometry, volumes, capacity area and perimeters		
7	Asanka (concept of pi): circular ethno-technology)	Mensuration (concept of pi)		
8	Foot and Hand counting: (Nsayam, anamon, basafa)	Perimeter and area measurement		
9	Geometrical artifact (*Kɛtɛ, asrɛnɛ and mukyia*)	Geometry (rectangles, Rhombus, similarity and congruence		
10	Game-based (Ludo, die rolling, *oware, dame*)	data collection, area measurement, perimeter		

APPENDIX I

STUDENTS INTERVIEW GUIDE

SECTION A: (Base on your exposal to the ethnomathematics lessons, kindly responds to this interview guide for me.)

1. How different was this teaching methods with me (researcher) from what you usually experience with your usual teachers?

……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………

2. How useful is the integration of Ethnomath approach in teaching the mathematics experimental lesson to you?

……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………

3. What effect does ethnomathematics approach of teaching has on your (students") interest in learning mathematics

……………………………………………………………………………………………………
……………………………………………………………………………………………………

4. What effect does ethnomathematics approach of teaching has on (your) students" motivation in learning mathematics

……………………………………………………………………………………………………
……………………………………………………………………………………………………

Students are to react to the following interview guide questions:

5. Do Akan riddles and puzzles project mathematical reasoning?

……………………………………………………………………………………………………
……………………………………………………………………………………………………

6. (IF YES) Can you give me one example?

……………………………………………………………………………………………………
……………………………………………………………………………………………………

7. Do you know the answer? Tell me then…

……………………………………………………………………………………………………

……………………………………………………………………………………………………

8. Give reason well.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

9. Can I give you a riddle just like yours but more mathematical to try?

……………………………………………………………………………………………………

……………………………………………………………………………………………………

10. Three men want to cross a river. They find a boat, but it is a very small boat. It will only hold 200 pounds. The men are named Okese, Honeho and Ketewa. Okese weighs 200 pounds, Honoho weights 120 pounds, and Ketewa weighs 80 pounds. How can they all get across? They might have to make several turns in the boat. Any idea?

……………………………………………………………………………………………………

……………………………………………………………………………………………………

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APPENDIX J

STUDENT ETHNOMATHEMATICS ACTIVITIES

1. ***Activity1****: Student in their groups construct the following Akan Adinkra symbols in their formal construction lesson.*
    1. "*Adinkrahene* (Chief of Adinkra)
    2. *Woforo dua pa a* (if you climb a tree)
    3. *Gye-Nyame* (Except God the Creator)
    4. *Mmere-dane* (Time Changes)
2. ***Activity 2****:* Student participants are to use the tallying concept to prepare a frequency distribution table for the occurrence of face of die thrown 48 times and observing the faces that turn up.
3. ***Activity 3:*** Students are to play Akan counting games such as pebble-picking games (*bantama-krakuro*) and link it to formal circular permutation concept. Prepare a table of circular permutation of 6!
4. ***Activity 4:*** *Students Activity in Playing the Game:* Students were put into groups to play the oware game by recognizing its rules and creating a linkage of counting in base four.
5. ***Activity 5 (Illustrative folktale***) Students in their Groups are to examined the following recreational mathematics to observed and report difficulty level, if any.

    "On Ananse's birthday, his grandmother cut 12 pieces of ofam, after he told him that he had invited twelve friends. However, only two friends arrived on time, and the rest came later".

    Question 1: If Ananse wishes to divide the 12 pieces of cake between his son Ntinkumah and himself, how many pieces of cake would each receive?

    Question 2: If we had 16 pieces of cake and four boys, can we divide them equally between them?

    Question 3: As we have six friends and 12 pieces of cake, how many pieces does each child receive?
6. ***Activity 6: (Riddle and Puzzles):*** Students in groups are drilled to find answers to the following puzzles through logical reasoning skills

    A man travelling with goat, tame lion and a yam want to cross a bridge. If the canon could pick only one item with the traveller at a time, how can the traveller cross the river with all his items unhurt?

7. ***Activity 8: (Akan Numeration and counting Skills):*** Students are drilled on how to count the Akan numeration orally to observe place value concepts

    1. *Do you know how to count the natural numbers and recognizes place value concepts in Akan language?*
    2. Would this knowledge in Akan ethnomathematics help one studying mathematics in the formal classroom?
    3. Do you know how to count numbers 1, 2, 3,…,100 in Akan Language?
    4. Can you read these numbers for me in Akan numeration?

        (v) 10,133

        (vi) 24,510,768

        (vii) 923,452,001,234

        (viii) 1,234,322,566,677

        (ix) How does the Akans identify the number/value 1,234,352,566,677

8. ***Activity 9:*** Students in their group represent sets statements and listing in Akan informal mathematics.

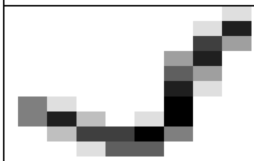
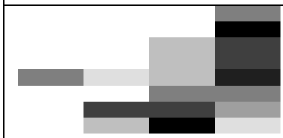
Set Concepts in statement form	**Formal Listing**	**Informal Akan set listing**
A={set of even numbers less than ten}	A={2, 4, 6, 8}	
B={Set of prime no. between 10 to 20}	B={11, 13, 17, 19}	
C={Set of odd numbers less than ten}	C={1, 3, 5, 7, 9}	
D={set of 3 common vegetables}	D={tomatoes, garden eggs, pepper}	
E={set of four fruits in sold in the market}	E{pear, mangoes, orange, pineapple}	
F={set of four things found in the kitchen}	F={earth-bowls, ladle, coal-pot, blender}	

9. ***Activity 10***: Students were asked to analyses the following word problems.

    1. ***Mensa*** and ***Anane*** shared 20 ***cedis*** in the ratio of 2:3 respectively, how many would each get?
    2. Amina and Abu shared Timpani in the ratio of 2:3 respectively. How many would each get?
    3. D"Ambrosio went to a supermarket to buy Pizza, suppergety, and cheese at the cost of $40. If the price index for pizza is twice that of Suppergety and the price of a pack of cheese is $2 more than suppergety, how much is the cost of each food item purchased?

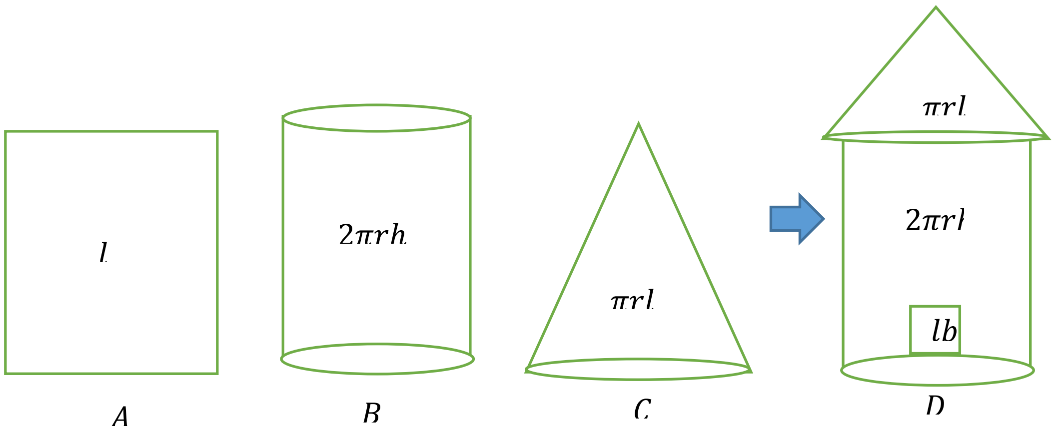
10. ***Activity 11***: Students are given various Akan ethnomathematical artifacts to measure their radius, diameter and circumference. They are to estimate the ratio of the

circumference to the observed diameter and report their answers in the following table.

Circular Artefact	**Name**	**Circumference (C)cm**	**Diameter (d)**	$\left(\frac{C}{d}\right) cm$
	Apotoyowa			
	Ahina			
	yaawa			
	Asanka			
	tapoli			
	Suhina			
	Waduro			

11. Activity 12: Students in their groups were asked to analyses the following mensuration problems.

Given the diagram in the following specimen A-D. if the rectangle in specimen A has length (l)=15cm, width (b)=10cm and the height of cylinder is 5cm with radius 8cm whiles the conical roof in specimen C has radius 12cm with height 2.5cm respectively. Find the total surface area of the building in spacemen D made out from A, B and C.



12. ***Activity 13***: Students were asked to find the perimeter and area of your tables top, marker board, classroom using arbitrary Akan ethnomathematics measurement using hand stretching, footing and palming. Compare with the formal SI unit measurement in cm, m and km.

4. Folklores [ ]

5. Gestures [ ]

6. Ethno-technology [ ]

7. Others:………………………………………………………………………

7. Do you have any mathematical idea that guides your production?
1. Not all [ ] 2. No [ ] 3. Not sure [ ] 4. Sometimes [ ] 5. Yes [ ]

8. Do students and Teachers buy or request your products for academic use (e.g. teaching and learning)
1. Not all [ ] 2. No [ ] 3. Not sure [ ] 4. Sometimes [ ] 5. Yes [ ]

9. Do you use mathematics method on your model techniques of instrument?
1. No [ ] 2. Yes [ ] Not sure [ ]

10. Have you taken any training to make instrument?
1. No [ ] 2. Yes [ ] Not sure [ ]

11. Which of the following scope of the Ghanaian core mathematics do your Akan ethnomathematics support its teaching and learning? *(Can tick as many as possible)*

1. Number and numerations [ ] 2. Algebra [ ]

3. Probability and statistics [ ] 4. Plane Geometry [ ]

5. Vectors and Transformation in Plane [ ] 6. Trigonometry

7. Problem solving and applications [ ] 8. Mensuration

12. Which of the following is the main reason people patronage on your product?
For Domestic use [ ]
For Educational purpose [ ]
For scientific research [ ]
For Decoration and tourism [ ]
Any other [ ]

13. Which of the following inform your creation/selling of ethnomathematics product
1. Government policy [ ]
2. Personal search for resourceful teaching [ ]
3. School initiatives [ ]
4. Societal needs [ ]
5. Students request [ ]
6. Stakeholders request [ ]

Thank you

APPENDIX L

AKANS INFORMAL NUMERATION OR COUNTING SYSTEMS

Hindu-Arabic counting	**Informal counting**	**Formal counting**	**Informal counting**	**Formal counting**	**Informal counting**	**Formal counting**	**Informal counting**	**Formal counting**	**Informal counting**
1	Baako	20	Aduonu	50	aduonum	80	aduowotwe	140	Oha-Aduannan
2	Mmienu	21	Aduonu-baako	51	Aduonum-baako	81	Aduowotwe-baako	150	Oha-Aduonnum
3	Mmiensa	22	Aduonu-mmienu	52		82		160	Aho-nsia
4	Anan	23	Aduonu-mmiensa	53		83		170	Oha-aduoson
5	Anum	24	Aduonu-nnan	…		…		180	Oha-aduowotwe
6	Nsia	…		60	aduosia	90	Aduokron	190	Oha Aduokron
7	Nson	30	Aduasa	61		91		200	Ahaanu
8	awotwe	31	Aduasa-baako	62		92		300	Ahaasa
9	Nkron	32	Aduasa-mmienu	63		93		400	Aha-nnan
10	Edu	33	Aduasa-mmiensa	64		…		500	Aha-nnum
11	Dubaako	…		..		100	ɔha	600	Aha-nsia
12	Du-mmienu	40	Aduanan	70	aduoson	101		700	Aha-nson
13	Du-	41	Aduanan-	71		102		800	Aha-

	mmiensa		baako						nnwotwe
14	Du-nnan	42		72		103		900	Aha-nkron
15	Du-nnum	43		73		…		1000	Apem
	…	…		…		110		1001	Apem-ne-baako
				80		120	Oha aduonu	1002	Apem-ne-mmienu
						130		…	Ope, Opepe, …

APPENDIX M

STUDENTS PERFORMANCE IN PRE-TEST AND POST TEST SCORES

S/n	Arts A Pre-Test	Arts B Pre-Test	Arts A Post-Test Scores	Arts B Post-Test Scores	Arts A Average Test Scores	Arts B Average Test Scores
1	39	39	68	62	47.03	54.92
2	38	36	64	61	44.96	54.03
3	30	18	28	43	30.94	40.61
4	34	32	47	55	36.19	51.03
5	27	5	34	53	28.22	45.89
6	20	20	40	37	25.23	31.48
7	36	30	53	54	40.89	47.93
8	30	14	35	50	33.83	44.62
9	41	27	46	62	43.38	57.74
10	49	53	72	73	56.48	68.16
11	40	49	78	65	48.02	57.62
12	28	21	41	48	34.73	43.14
13	38	25	44	57	44.03	52.82
14	41	30	57	62	46.5	55.18
15	34	26	47	54	37.56	48.32
16	37	18	34	57	36.42	52.79
17	29	18	43	48	34.17	42.14
18	39	43	71	62	43.71	55.01
19	33	28	54	58	36.27	51.83
20	36	31	56	63	37.72	57.14
21	43	44	70	64	46.38	57.87
22	38	27	54	61	44.9	53.75
23	29	22	47	48	35.69	42.12
24	39	26	53	60	44.18	53.07
25	38	44	68	57	45.28	51.38
26	46	43	69	70	52.03	63.86
27	29	17	39	49	34.57	43.87
28	30	24	45	48	36.46	42.73
29	39	63	88	57	50.28	51.05
30	47	57	82	66	52	59.88
31	50	59	84	72	56.87	65.28
32	45	36	63	72	49.74	64.63
33	33	29	45	50	36.83	45.93
34	48	62	79	67	55.56	62.8

35	56	53	80	84	61.49	76.7
36	33	29	51	55	32.83	48.94
37	43	36	55	67	46.86	61.98
38	34	30	58	58	39.68	50.97
39		44		60		55.59
40		42		63		57.66
41		51		60		52.52
42		34		60		52.9
43		39		57		54.14
44		54		61		57.29
45		62		58		64.63
46		53		60		45.93
47		29		63		62.8
48		36		60		76.7

APPENDIX N:

ETHNOMATHEMATICS DEMONSTRATION LESSON

DEMONSTRATION LESSON 1: NUMBERS AND NUMERATIONS:

SCHOOL: Experimental School A, B and C
CLASS: Experimental Group A
NUMBER ON ROLL: 38
AVERAGE AGE: 15+
TOPIC: Real number system

REFERENCE:

Allotey, G. & Buckwell, G. (2005). Macmillan Senior High School Mathematics for West Africa. (Book 1, 2 & 3)

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MOE (2010). Teaching syllabus for Core Mathematics, CRDD

Mathematics Association of Ghana (2009). Core Mathematics for Senior Schools Mathematics for West Africa (Books 1, 2 & 3)

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Statement of intent and Specific Objectives

Numeration concept is believed to be part of every culture so far as the mind conceived of body of numbers in counting for quantity. The topic seeks to introduce students into real number systems, the first scope of secondary core mathematics in the syllabus. Students are guided through ethnomathematics moves to establish interconnection between the formal number and numeration systems in relation to informal one existence among the Akans. We are to apply the conceptual framework behind number and numeration concepts from the formal curriculum to compare the informal ones. The lesson is guided by the following specific objectives. At the end of the lesson, it is expected of students to perform the following abilities:

1. *Describe* the place value concepts in natural base ten in the formal and informal structure in the number system (Knowledge)
2. *Categorize* real number systems into various compositions as rational and irrational, natural and counting, even and odd, prime and composite in finite and infinite form, (comprehension).
3. *Operate* on at least two binary number concepts through addition, subtraction, multiplication and division (Application)
4. *express* very large or small numbers in standard form as $(k \times 10^b)$. (Analysis)
5. *distinguish* formal numeration structure and informal numeration concepts, (synthesis/innovation/creativity)

review Akans numeration concept to connect with the formal structure of numbers based on place value(Evaluation).

Formal curriculum structure and scope, ethnomathematical moves and mathematical concept formations.

S/n	Topic from the formal (school) curriculum	Basic Concept	Curriculum structure for school level	Ethnomathematical moves	Mathematical Concept formation
1	Numbers and Numeration.	Real number system	SHS 1 &2	Finger counting Oral numeration Debt tallying Counting-based games	Number and counting system from the informal perspective, grouping, ordering, sorting etc

Teaching Resources: Flash cards of number concepts, bundle sticks, marbles.

TEACHER-LEARNER ACTIVITIES

Introduction: Let students sing a traditional song with number recognitions and identify number and numerations as well as mathematical concepts the song lyrics presents. Example, *baako, mmienu, mmiensa, ne nnan; ne nyinaa kabom a 3y3 du* [i.e. one, two, three and four add up to make ten]

Key content and mathematical concept/construct: Recognition of numbers, number patterns, series and sequences, place values as well as concepts of addition.

Lesson Presentations

Guide students revise natural numbers, whole numbers and integers use the knowledge to explore the oral numeration of numbers from $1, 2, 3, \dots, \infty$ by looking at it from formal structural systems to information presentation.

$$1, 2, 3, 4, 5, 6, 7, 8, 8, 10, 11, 12, \dots, 20, 21, 22, \dots, 30, 31, 32, \dots, \infty.$$

The formal versus informal numeration or counting system

Formal counting	Informal counting	Formal counting	Informal counting	Formal counting	Informal counting	Formal counting	Informal counting	Formal counting	Informal counting
1	Baako	20	Aduonu	50	aduonum	80	aduowotwe	140	Oha-Aduannan
2	Mmienu	21	Aduonu-baako	51	Aduonum-baako	81	Aduowotwe-baako	150	Oha-Aduonnum
3	Mmiensa	22	Aduonu-mmienu	52		82		160	Aho-nsia
4	Anan	23	Aduonu-mmiensa	53		83		170	Oha-aduoson
5	Anum	24	Aduonu-nnan	…		…		180	Oha-aduowotwe
6	Nsia	…		60	aduosia	90	Aduokron	190	Oha Aduokron
7	Nson	30	Aduasa	61		91		200	Ahaanu
8	awotwe	31	Aduasa-baako	62		92		300	Ahaasa
9	Nkron	32	Aduasa-mmienu	63		93		400	Aha-nnan
10	Edu	33	Aduasa-mmiensa	64		…		500	Aha-nnum
11	Dubaako	…		..		100	ɔha	600	Aha-nsia
12	Du-mmienu	40	Aduanan	70	aduoson	101		700	Aha-nson
13	Du-	41	Aduanan-	71		102		800	Aha-

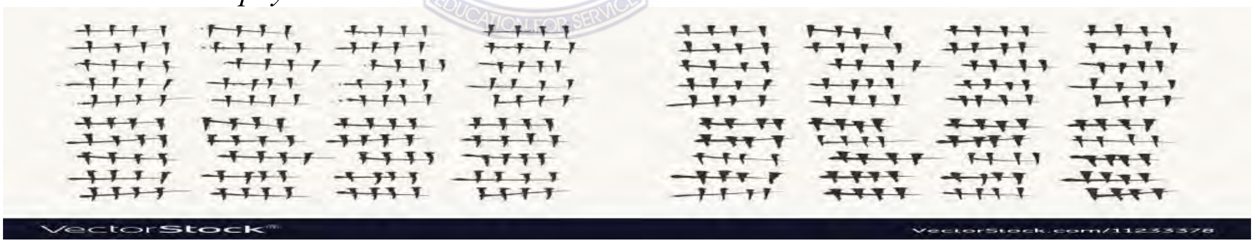
	mmiensa		baako					nnwotwe
14	Du-nnan	42		72	103		900	Aha-nkron
15	Du-nnum	43		73	…		1000	Apem
.	…	…		…	110		1001	Apem-ne-baako
.				80	120	Oha aduonu	1002	Apem-ne-mmienu
∞					130		…	Ope, Opepe, …

Key content and mathematical concept/construct: Recognition of numbers, number patterns, series and sequences, place values as well as concepts of addition
Put students into their cooperate groups to discuss way they can arbitrary represent the informal numbers to conform to some formal way of representing them, e.g using strokes of lines or arbitral symbols.

Teaching Resources: Strokes

Guide students to distinguish between rational and irrational numbers and draw Venn diagram to illustrate the relationship between members of the real number system

Key content and mathematical concept/construct: Rational numbers can be expresses as $\frac{a}{b}$ where a and b are real numbers and $b \neq 0$, otherwise, it is irrational number.
Let students use Debt tallying to categorize numbers into various numeration systems
Ethnomath move: using debt tallying ethnomathematics: The tallying is used traditionally to signify records of the occurrences of events with time bounds. Example, the time of owing somebody and probably mode of payment methods. This has ethnomathematics concepts believed to conform to number counting system, statistical tools of collection and organizing data and the probability of occurrences of events such as to *borrow* or to *pay*.



Tallying system of counting adapted from traditional ethnomathematics.
The tallying system could be modified to assist students in diverse mathematical concepts that relate statistics and number systems.

The use of figure counting*:* Let students demonstrate how the figure counting could be used to illustrate number concepts and binary operation numbers.
Key content and ethnomath construct: The figure counting system is used traditionally to induce number and numeration concept with means of operation.

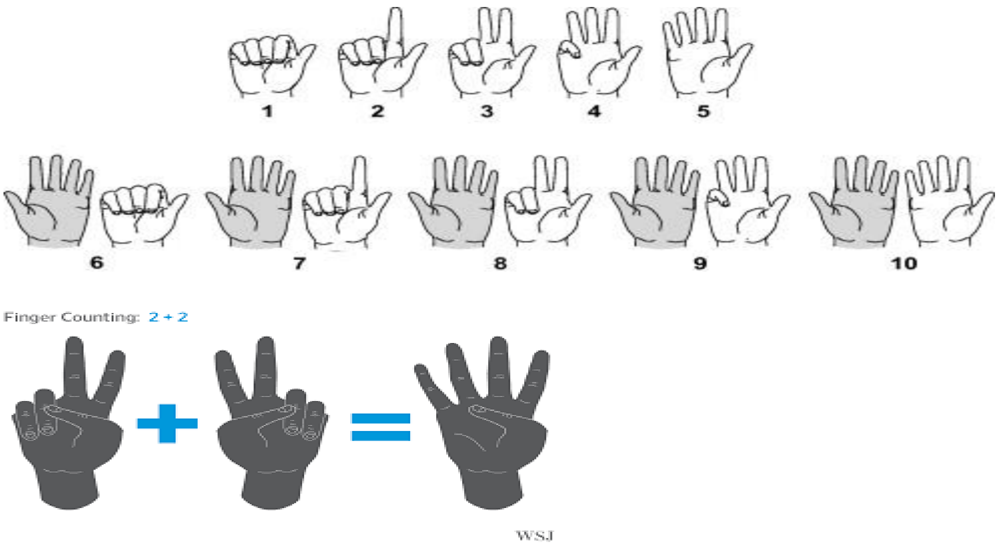


Fig 2: figure counting techniques and operational sum

The tallying is used traditionally to signify records of the occurrences of events with time bounds. Example, the time of owing somebody and probably mode of payment methods.
Let students use counting game techniques to explore more on number systems and numeration using ludo and Oware games as demonstrated below.

The Ludo game is one among the famous ancient board traditional games. It‟s a two player game, which is enjoyed and played by almost everyone. It‟s the most popular ever happening games in many countries of which Ghana is of no exception. The game is played on board which has blocks and paths marked on it, so start with it and move the ludo pieces as per the shuffled dice. The dice cup is number 1-6 which helps to shuffle the dice properly and play over the game. The middle squares form the home column for each colour and cannot be landed upon by other colours. The middle of the cross forms a large square which is the 'home' area and which is divided into 4 home triangles, one of each colour.

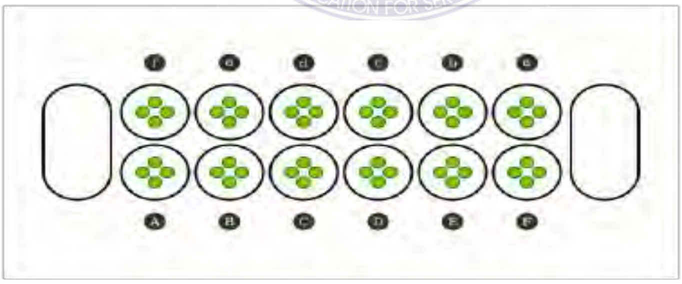
Players take turns in a clockwise order; highest throw of the die starts. In each throw, the player decides which piece to move. A piece simply moves in a clockwise direction around the track given by the number thrown. If no piece can legally move according to the number thrown, play passes to the next player. A throw of 6 gives another turn. A player must throw a 6 to move a piece from the starting circle onto the first square on the track. The piece moves 6 squares around the circuit beginning with the appropriately coloured start square (and the player then has another turn). If a piece

lands on a piece of a different colour, the piece jumped upon is returned to its starting circle. If a piece lands upon a piece of the same colour, this forms a block. This block cannot be passed or landed on by any opposing piece.
Winning: When a piece has circumnavigated the board, it proceeds up the home column. A piece can only be moved onto the home triangle by an exact throw. The first person to move all 4 pieces into the home triangle wins.
Students drills themselves among their group members to explore on the number patterns which are thrown on luck/probabilistic way and categorize number of times prime, even and odd numbers turn up along the throw of the dies.

The Oware Game: is one of the famous and popular games that has ethnomathematics implicative to the teaching and learning of mathematical concepts. It possess the ability to recognize numbers, conceive natural counting in base four (since the marbles must be started and won on the bases of four counts) and among others.

Equipment and Initial Setup:
To play ***oware abapa*** you will need a game board (in the absence of this is a drilled hole on the ground) and **forty-eight game pieces**, which are so-called seeds of cowries or pebbles or palm kernel pebbles etc. Usually the board consists of **two rows of six holes** located at opposite sides. Two larger holes on the sides of the board are used to store the seeds players capture during the match. It is said that the bottom row belongs to the player who moves 1st, named **south**, and the upper row to the second player or **north**.

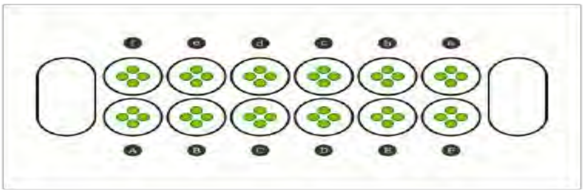
Oware board in its starting position: Each of the playing holes contains exactly four seeds.
In the starting position, each hole excluding the two largest ones (stores) contains exactly four seeds. In this position the south player will make his 1st move, followed by a move by the north player and so on until the game ends.



Goal of the Game: The goal of oware is to **capture the greatest amount** of seeds as possible to conceive on numbers of counting and base four algorithm. To do so, players make moves in alternate turns until one of them has captured more than 24 seeds. The player who captured more seeds than his opponent when the game ends wins the match. It may also happen that both players have captured the same amount of seeds at the end. In this case, neither player wins the game and the match is said to have ended in a draw.

Playing the Game: Each move of the game is done in three phases: **collecting**, **sowing** and **capturing**. During the sowing a player distributes the collected seeds along the board, and during the capture phase the player takes, if possible, the seeds found in the pits of the opponent. A seed is **Collected** in the 1st phase of a movement, the player who is to move chooses one of the holes on his own side of the board and collects all the seeds on it, leaving the hole empty. Subsequently, these seeds will be distributed on the board during the sowing phase. A player may collect the seeds from any of the holes that belong to him if it contains one or more seeds, only with the exception that after making the move his opponent must be able to play. Therefore, a move that would leave all the holes empty on the opponent's side is not legal.

Sowing Seeds :During sowing, the player distributes the seeds collected in the rst phase along the board in a **counterclockwise** direction; dropping **one seed** in each of the playing holes until all the seeds are distributed. A player will never sow on the holes used for storage.



Sowing process in oware: South sows 4 seeds, distributing them around the board one by one in a counterclockwise direction. After sowing the seeds, the hole from which the player has collected seeds will be empty. It may well be the case that the player sows twelve or more seeds, in which case the player will sow them going round around the board, dropping one seed in each hole in every round, but never dropping a seed in the hole from which the seeds were collected.

Capturing Seeds: When the last sown seed is dropped in one of the holes belonging to the opponent, and after dropping the seed the hole contains **exactly two or three seeds**, the player will capture them. Taking all the seeds from the hole and saving them in his own store. When the hole immediately to the right of the last pit from which seeds were captured contains also two or three seeds, the player will capture them too. And so on until the player cannot capture more seeds, always taking into account that players can only capture seeds **from their opponents' holes** and never from their own holes. After sowing three seeds, collected from the F hole, south captures 5 seeds from holes" b and c. Note that a player can never capture all the seeds of the adversary. If a player makes a move that would capture all the seeds on the opponent's side, that player will sow normally but will not capture any seeds.

End of the Game: Typically, the game is over when one of the players has captured more than 24 seeds or when both of the players have captured 24 seeds. It may also happen that a player cannot make any legal move

Key content and mathematical construct/concepts:
Ludo and oware games has long been used as an intuitive method of conserving number and numerations concepte. They possess the ability to recognize numbers, conceive natural counting in base four (since the marbles must be started and won on the bases of four counts) and among others number pattern concepts. We drill on the type of number concepts the game might suggest such as natural numbers, counting numbers, even numbers, odd numbers, integers, prime numbers etc.

Key content and mathematical concept/construct: Recognizing that the total interior angles of a regular polygon is $180(n-2)$ and exterior angles of any polygon is 360^0

Students ***turn to neighbor*** to discuss solution

Random call to select/find students‟ response.

Conclusion: summarize lesson by allowing students to compare the formal number and numeration representations to the informal traditional/indigenous application of number concepts are how they were conceived through intuitive games in oral tradition.

Applications: Students would be able to use the knowledge gained to appreciate the mathematical implication of indigenous number theory games found in their communities. They can arbitrary generate number symbols to rebrand the oral tradition to the most formal approach which could later be considered in curriculum development in Ghana.

Evaluation: Students perform the following problem solving on real number systems as a group work.
Draw a Venn diagram to represent the relationship between the members of the real number systems by taking into consideration regions of subsets.
List the following infinite set of numbers from

$\alpha \; formal$

$\beta \; Informal$

Even numbers
Odd numbers
Prime numbers
Counting numbers between 95 to 130
Multiples of 5, 7, 8 and 10

Identify four traditional indigenous games that illustrate number and numeration concepts
Given that $a = //// \not{} \; b = // \; and \; c = ///,$
show that $a + (b + c) = (a + b) + c.$
what property is this?
Remarks:

DEMONSTRATION LESSON 2: PLANE GEOMETRY: PROPERTIES OF PLANE FIGURES

SCHOOL: Experimental School A, B and C
CLASS: Experimental Group A
NUMBER ON ROLL: 67
AVERAGE AGE: 15+
SUB-TOPIC: Properties of Plane figures

REFERENCE:

Allotey, G. & Buckwell, G. (2005). Macmillan Senior High School Mathematics for West Africa. (Book 1, 2 & 3)

Asiedu, P. (2011). Core Mathematics for West African Senior High Schools, *Akiola Publications Ltd.*

Bassett, D. R., Jr, Toth, L. P., LaMunion, S. R., & Crouter, S. E. (2017). Step Counting: A Review of Measurement Considerations and Health-Related Applications. *Sports medicine (Auckland, N.Z.)*, *47*(7), 1303–1315. doi:10.1007/s40279-016-0663-1

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Statement of intent and Specific Objectives

The topic seeks to introduce students into properties of plane figures. Students are guided through ethnomathematics moves to establish interconnection between the formal representation of Euclidean geometrical systems in relation to informal geometrical concepts in their real life situations and environment. We are to apply the conceptual framework behind plane geometry to traditional technology, ways of measuring length and angles. The lesson is guided by the following specific objectives.

Identify various properties of special plane figures such as triangle, squares, circles, cones and cylinders etc. in 3-D (Knowledge)

1. *Measure ethno-geometric figures (indigenous technologies that has geometrical applications)* and relate it to the formal Euclidean geometry and applications (understanding/psychomotor domain).
2. *Use* the rule for sum of internal angles of triangles and quadrilaterals in solving plane geometry problems and measure the angular dimension of traditional 3-D objects in the locality (Application)
3. *calculate* an angle at a *point* and make application *to* informal geometry (Analysis)
4. *Draw* at least three (3) plane figures, geometrical shapes and combine them to form indigenous traditional 3-dimensional objects a word problem questions with formulated variables and solutions, (synthesis)
5. *compare* at least three (3) features of geometrical shapes drawn with the informal artifacts applied in different things in the community. (Evaluation).

Relevance Previous Knowledge (RPK): Students interact with different forms of geometrical shapes in their neighbourhood such as rectangular buildings, triangular representations etc.

S/n	Topic from the	Curriculum	Ethnomathematical moves	Mathematical

	formal (school) curriculum	**structure for school level**		**Concept formation**
2	Plane Geometry	SHS 1, 2 & 3	Measurement through foot and finger length Geometrical shapes from the environment	Measurement of Length and Distance

TEACHER-LEARNER ACTIVITIES

Teaching Resources: Flash cards of geometrical shapes, triangle, square, pentagon, circles, pictures, buildings
Introduction: Let students identify plane shapes, geometrical shapes in two and three dimensional space objects

Key content and mathematical concept/construct: Recognition of Plane geometry on 2-D and 3-D. Revise different types of triangles including scalene, isosceles equilateral and right-angled triangles.

Lesson Presentations

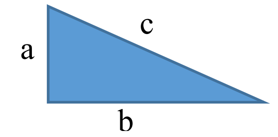
1. Guide students to establish the properties of plane geometry such as isosceles and equilateral triangles. E.g. (i) the line of symmetry of an isosceles triangle bisects the base and the angle opposite it, and is perpendicular to the base, (ii) equilateral triangles have three lines of symmetry in the plane and the lines are congruent.

Key content and mathematical concept/construct: Recognition properties of plane figures and plane geometry: exploration of lines of symmetry, congruent of angles, bisection of lines, parallel systems of lines, centroid of plane figures, perpendicular dimension of traditional buildings and other materials explored on the environment.

2. Let students measure the length and angles of plane figures explored formally and informal arbitral measurement (through foot and finger length counting) and scientific measurements (rulers and protractors)

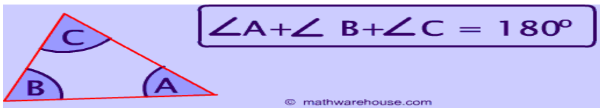
Ethnomaths teaching resources:
Step counting and hand counting has long been used as a method of measuring distance. Starting in the mid-1900s, researchers became interested in using steps per day to quantify physical activity that needs measurement of length and tracing angles. Steps counting have several advantages as a metric for assessing physical activity: they are intuitive, easy to measure, objective, and they represent a fundamental unit of human arbitrary counting activity. However, they can be used as arbitral measurement tools when scientific tools are absent to facilitate teaching and learning, (David et al., 2016)

Guide students to use practical activities, including the use of the geoboard to identify the right-angled triangle and discover the relationship between the hypotenuse and the other two sides. $c^2 = a^2 + b^2$



Key content and mathematical concept/construct: Recognition of Pythagoras theorem based on Pythagorean principles.

Put Students in their cooperate group and use ***three-minutes-pause*** to brainstorm about the generalized concept of *sum of interior angles of a triangle.* Students ***Think square-share*** to tell what you know about total interior angle of triangle (think for 5 seconds, pair and now we will begin with sharing 1 idea you spoke about).



Students in cooperate groups identify from their environment, application of angles in 3-D objects from in their community and measure them. Student *think-pair-share* through *random call* to deduce the total angles of a polygon as $180(n-2)$. Find the total interior angles for a polygon of 6 sides

Key content and mathematical concept/construct: Recognizing that the total interior angles of a regular polygon is $180(n-2)$ and exterior angles of any polygon is 360^0

Students ***turn to neighbor*** to discuss solution
Random call to select/find students‟ response.

Conclusion: summarize lesson by allowing students to compare the formal geometric representations to the informal traditional/indigenous application.

Applications: Students would be able to use the knowledge gained to appreciate the mathematical implication of indigenous technology found in their communities. They can measure, draw and find the dimensions of buildings and other material things found in their communities.

Evaluation: Students perform the following problem solving on plane geometry.
Agya Kwasi has a rectangular plot enclosed by angles $67^0, and\ 53^0$. Find the third angle enclosed by his plot of land.

Draw any four plane figures
Identify four traditional indigenous artifacts from your community that has geometrical applications of what you have drew.
Remarks:

DEMONSTRATION LESSON 3: PERIMETERS AND AREAS AND VOLUMES

SCHOOL: Experimental School A, B and C
CLASS: Experimental Group A
NUMBER ON ROLL: 67
AVERAGE AGE: 15+
SUB-TOPIC: Perimeters, Areas and volumes

REFERENCE:

Allotey, G. & Buckwell, G. (2005). Macmillan Senior High School Mathematics for West Africa. (Book 1, 2 & 3)

Asiedu, P. (2011). Core Mathematics for West African Senior High Schools, *Akiola Publications Ltd.*

Bassett, D. R., Jr, Toth, L. P., LaMunion, S. R., & Crouter, S. E. (2017). Step Counting: A Review of Measurement Considerations and Health-Related Applications. *Sports medicine (Auckland, N.Z.)*, *47*(7), 1303–1315. doi:10.1007/s40279-016-0663-1

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Statement of intent and Specific Objectives

Mensuration as it is popularly called in Ghanaian core mathematics is integration of mathematical concepts about perimeters, lengths, areas and volumes of two and three dimensional objects respectively. Quite a number of Ghanaians students perceive this topic as difficult due to its formulae based computation. We explore in this scope content spell out by the core mathematics syllabus, certain concepts for which majority of Ghanaians ethnomathematics support its resourceful teaching.

At the end of the lesson, it is expected of students to perform the following abilities:

List some Ghanaian ethnomathematics concepts of application of perimeters, areas and volumes found in Most Ghanaian communities, *(Knowledge)*

Generalize the concepts of area of circle, volumes of cylinder and cone, (Understanding).

Solve for at least three problems each with given radius, the total surface areas of cones and cylinders and apply them to practical traditional buildings and artifacts, (Application)

express very large or small numbers in standard form as $(k \times 10^b)$. (Analysis)

distinguish between formal mensuration structure and informal mensuration concepts inherent in practical applications in indigenous technologies and games, (synthesis/innovation/creativity)

appraise and make recommendations the need to appreciate Ghanaian view of ethnomathematics to be included in the formal curriculum structure, (Evaluation).

Table 1: Formal curriculum structure and scope, ethnomathematical moves and mathematical concept formations.

S/n	Topic from the formal (school) curriculum	Curriculum structure for school level	Ethnomathematical moves	Mathematical Concept formation
3	Mensuration	SHS 1, 2 & 3	Area and perimeter of home-based artefacts Volumes of pots Construction of indigenous circular technology Earth-ware bowls	Perimeters, Areas and volume

Teaching Resources: Pictures of geometrical shapes, cones, cylinders, circles, pictures of cylindrical buildings with conical roof.

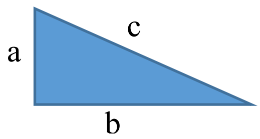
TEACHER-LEARNER ACTIVITIES

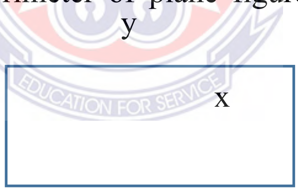
Introduction: Draw a rectangle, circle, cylinder and a cone on the board and ask students to identify them and suggest things found from the community they live in that have commonness and similarities as ethnomathematics on mensuration.

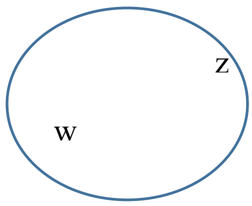
Key content and mathematical concept/construct: Recognition of 2-dimensional and 3-dimensional objects that suggest perimeters, areas and volumes.

Lesson Presentations

Guide students measure the perimeter of plane figures and apply it to things found similarly in their neighborhood.



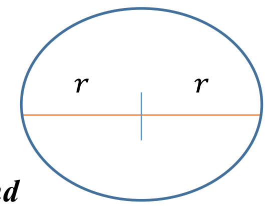




$P = C = 2\pi r$

$p = a + b + c$ $p = w + x + y + z$

Introduce the concept of pi (π) as ratio of circumference to diameter of any given circular shape. Use this revision to help students deduce the generalized concept of circumference and diameter



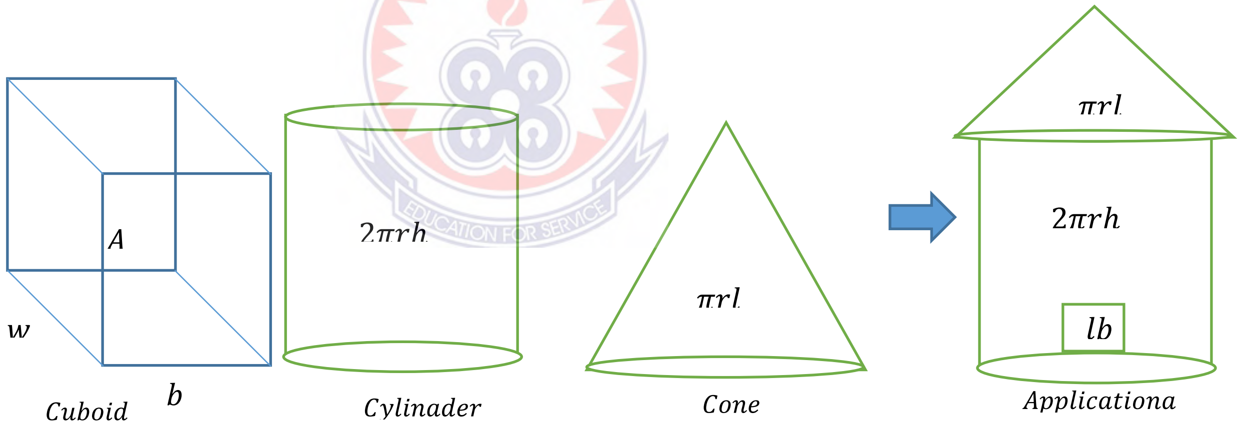
$d = r + r = 2r$

Key content and mathematical concept/construct: The concept of Pi(π) is a Greek alphabet that is used to arbitrary represent a constant number in circles which is proportional to the ratio of circumference to the diameter. The pi(π) is a natural constant of value $pi(\pi) = 3.141592653589793$ which cannot be expressed as $\frac{a}{b}, b \neq 0$ and hence, considered as an irrational number. The generalized concept of pi(π) is given as

$$\pi = \frac{C}{d} = \frac{C}{2\pi}, where\ d = r + r = 2r\ and\ \pi = 3{,}142 \ldots$$
$$C = \pi d = 2\pi r \text{ and}$$
$$d = C/\pi$$

Put students into their cooperate group/unit to discussed the total surface area of certain 3-D objects such as cones, cylinders and pyramids and make application to Ghanaian ethnomathematics.

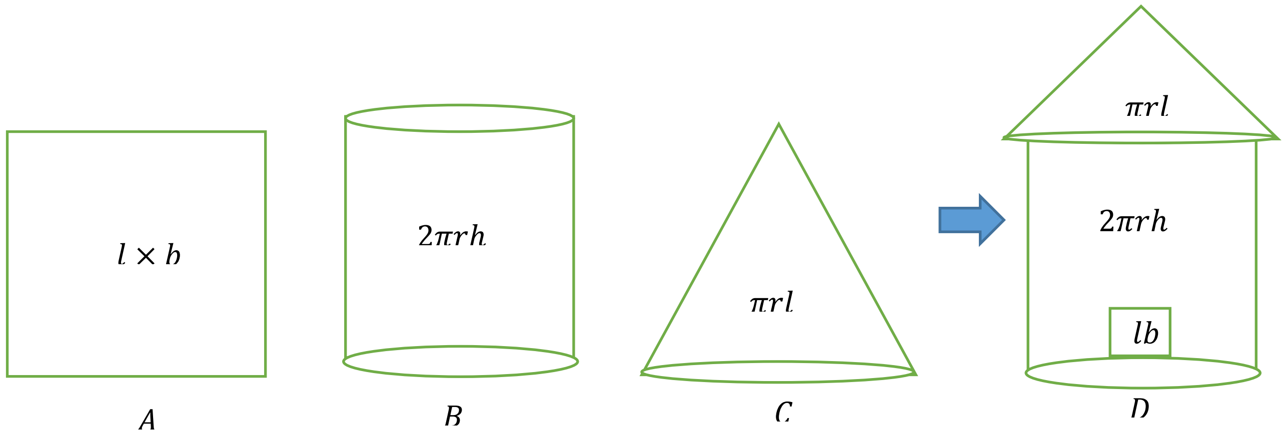
Key content and mathematical concept/construct: The concept of total surface area (TSA) of cylinder, TSA of cones and pyramids
Let students discuss the generalized concepts of volumes, emphasis on cuboid, cylinders and cones.



Key content and mathematical concept/construct: The concept of volumes of cylinder, volumes of cones and volumes of pyramids
Students in the same cooperate group discusses an application of generalized concepts in various problem solving strategies relating to ethnomathematics as seen below:

Key content and mathematical concept/construct: The concept of volumes of cylinder, volumes of cones and volumes of pyramids. Concepts of TSA of 2-D and 3-D respectively.

Ethnomath Constructs: To bridge the gap between cultural-based mathematics and formal mathematics, there is the need to mathematicised culturally-based mathematics. We mathematize the mensuration concepts in with typical ethnomathematics of traditional artefacts to integrate the whole mensuration concepts as exemplified in the problem below



Exemplification of mensuration problems with ethnomathematics application.

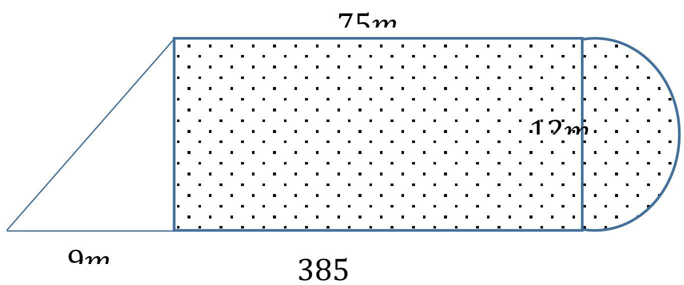
In the teaching of mensuration, ethnomathematics could be used to exemplify various applications of ethnomathematics ideas adapted to suit the child‟s environment. In the teaching of total surface area for specimen A, B and C, a compound of this three could be mathematicised to consist of specimen D where all these individual geometrical and area concepts have been put together. Let a mathematical problem be crafted for students to find a total surface area of D excluding the rectangular entrance.

Conclusion: Summarize lesson by allowing students to compare the formal generalized concepts of areas perimeters and volumes to ethnomathematical applications in Ghanaian Communities- traditional/indigenous application.

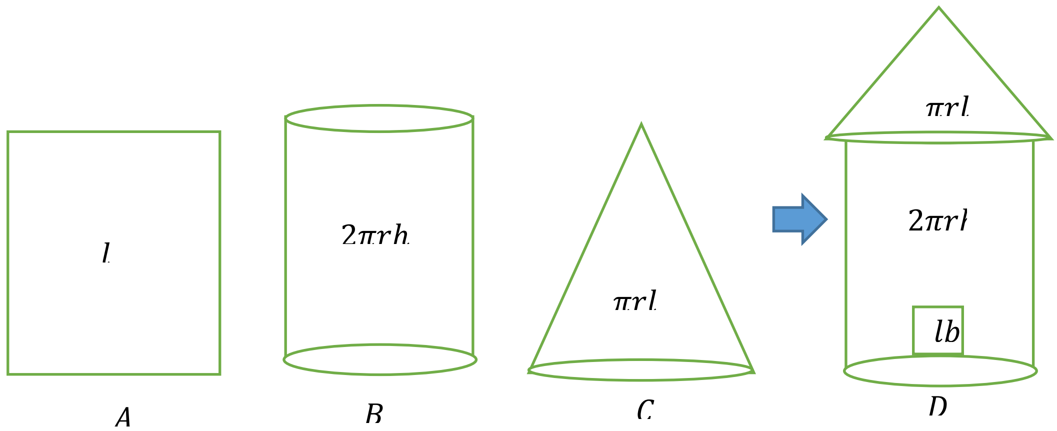
Applications: Students would be able to use the knowledge gained to appreciate the mathematical implication of indigenous technology found in their communities. They can measure perimeters of fields and buildings and site plans, draw 2-D and 3-D objects that are found in their communities and find the dimensions, perimeters, total surface areas and volumes of buildings and other material things found in their communities.

Evaluation: Students perform the following problem solving on mensuration

Agya Koo has a rectangular plot enclosed with rectangular field with triangular and semi-circular ends as shown below. Find the Perimeter and total surface area of the plot



Given the diagram in the following specimen A-D. if the rectangle in specimen A has length (l)=15cm, width (b)=10cm and the height of cylinder is 5cm with radius 8cm whiles the conical roof in specimen C has radius 12cm with height 2.5cm respectively



1. Find the total surface area of the building in spacemen D made out from A, B and C.
2. Estimate the volume of the building
3. If painting only the external wall will cost GHS 5 per unit m, find the amount of cost the owner has to pay in the painting.
4. Draw any four plane figures made in your environment that you believe is made out of mensuration applications
5. Identify four traditional indigenous artifacts from your community that has mensuration applications of what you have drew.

Remarks:

DEMONSTRATION LESSON 4: PROBABILITY AND STATISTICS

SCHEME OF LEARNING 4: MICRO-TEACHING ON ETHNOMATHEMATICS
PROBABILITY AND STATISTICS: Probability
SCHOOL: Experimental School A, B and C
CLASS: Experimental Group A
NUMBER ON ROLL: 67
AVERAGE AGE: 15+
TOPIC: Probability measure of an events

REFERENCE:

Allotey, G. & Buckwell, G. (2005). Macmillan Senior High School Mathematics for West Africa. (Book 1, 2 & 3)

Asiedu, P. (2011). Core Mathematics for West African Senior High Schools, *Akiola Publications Ltd.*

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Mereku, D. K., & Mereku, C. W. K., (2013). *Ghanaian case Study of Singing Games in Ethnomathematics*. Journal of African Culture and International Understanding. *6(1),16-23, Olusegun Obasanjo Library, Abeokuta, Nigeria.*

Statement of intent and Specific Objectives

Probability is an aspect of mathematics that consider theories and computation of the likely of an event $P(A)$ occurring of not occurring $P(A^c)$. The topic seeks to introduce students into probability and statistics, the fourth scope of secondary core mathematics in the syllabus. Students are guided through ethnomathematics moves to establish interconnection between the formal mathematical expectation of the likelihood of an event occurring in a single experiment such as the throw of coin, die and other chance-game of ethnomathematics in the Ghanaian context. We are to apply the conceptual framework behind the axioms of probability measurability of an event occurring in formal curriculum implementation and reconciling it to what the informal ethnomathematics have for us. The lesson is guided by the following specific objectives.

At the end of the lesson, it is expected of students to perform the following abilities:

List at least four (4) activities that create chances or likelihood of an event occurring (Knowledge)

State three (3) axioms of probability measure of an event A occurring, (Understanding/comprehension).

Apply the rules of probability to solve at least three (3) problems on probability of an event A, B or C occurring. (Application)

express addictive and multiplicative probability of event A, B and C occurring *as* $P(AUB) = p(A) + P(B)$and $P(A \cap B \cap C) = P(A) \times P(B) \times P(C)$, (Analysis)

Link and *find* ethnomathematics activities in the form of games to measurable probabilities, (synthesis/innovation/creativity)
combine the concept of probability of events A, B and C to their compliments $P(A^c), P(B^C)$ *and* $P(C^C)$ in at least three (3) given problems on chance from ethnomathematics settings, (Evaluation).

Formal curriculum structure and scope, ethnomathematical moves and mathematical concept formations.

S/n	Topic from the formal (school) curriculum	Curriculum structure for school level	Ethnomathematical moves	Mathematical Concept formation
5	Statistics and Probability	SHS 1 & 2	Games, eg. Ahyehyeaba, pilolo Counting systems Grouping and sorting things Arranging items in ascending or descending order Tracing and drawing emblems Tallying for debts	The concept of events and sample space probability measure Axioms of probability Compliment of event Addictive laws of probability Multiplicative laws of probability

Teaching Resources: Playing card, Ludo die, students, ethno-games, pebbles

TEACHER-LEARNER ACTIVITIES

Introduction: Let students mention some activities they are familiar with that create chances. E.g. football games, winning spur, gambling activities, etc.

Key content and mathematical concept/construct: Recognition of probabilistic activities, events and possible chance

Lesson Presentations

Guide students list all the possible chances in the given activity and experiment mentioned in the introduction and guide identify events and sample space.

$$1, 2, 3, 4, 5, 6, 7, 8, 8, 10, 11, 12, \ldots, 20, 21, 22, \ldots, 30, 31, 32, \ldots, \infty.$$

Key content and mathematical concept/construct: Recognition

Drill students to brainstorm the definition of probability and state its axioms or properties

Key content and mathematical concept/construct: Recognition of $P(A) = \frac{n(E)}{n(S)}$, $n(S) \neq 0, and$ probability measure of A is bounded as $0 \leq P(A) \leq 1$

Guide students solve problems involving probability measure by considering the axioms and

Key content and mathematical concept/construct: Recognition properties. Let students note the complement laws, additive and multiplicative laws of probability measure of event A, B and C in single and compound events.

Key content and mathematical concept/construct: Recognition of addictive law of probability as $P(AUB) = P(A) + P(B)$as mutually exclusive $P(AUB) = P(A) + P(B) - P(AnB)$as independent events. For multiplicative law, $P(AnBnC) = P(A) \times P(B) \times P(C)$

Put students into cooperate groups to explore on ethnomathematics moves: games and other cultural dynamics that create chances, e.g. pebble-in-fist-game, pebble-picking game, Ludo game, throwing of die. Let them compute each individual chances/probability of winning the game, picking pebbles number of times with measurable probability, throwing two dies to investigate compound events etc.

Rolling of Die (s):

The die is six sided cubic-like 3-dimensional object that is used to usually play the Ludo game or perhaps thrown for experimenting luck. A throw of the faces label $S = \{1, 2, 3, 4, 5, 6\}$consistude the sample space of all possible occurrences of event given each face $\frac{1}{6}$ probability measure.

Students play two dies together and establish a 6×6 possible occurrence of the paired results of the two dies as shown bellow

Die 1						
	(1, 1)	*1,2*	*(1, 3)*	*(1, 4)*	*(1, 5)*	*(1, 6)*
	(2, 1)	*(2, 2)*	*(2, 3)*	*(2, 4)*	*(2, 5)*	*(2, 6)*
	(3, 1)	*(3, 2)*	*(3, 3)*	*(3, 4)*	*(3, 5)*	*(3, 6)*
	(4, 1)	*(4, 2)*	*(4, 3)*	*(4, 4)*	*(4, 5)*	*(4, 6)*
Die 2	*(5, 1)*	*(5, 2)*	*(5, 3)*	*(5, 4)*	*(5, 5)*	*(5, 6)*
	(6, 1)	*(6, 2)*	*(6, 3)*	*(6, 4)*	*(6, 5)*	*(6, 6)*

Key content and mathematical concept/construct: Probability measure of pairwise events

Throwing of Coin:

Similarly, the coin is two sided flat-like 3-dimensional object that is tossed to usually select choices in game play such as football, other game starts or perhaps thrown for experimenting luck. A throw of the faces label $S = \{Head\ (H)\ or\ Tail(T)\} = \{1, 2, \}$consistude the sample space of all possible occurrences of event given each face $\frac{1}{2}$ probability measure. We can throw two coins, or a coin and a die together to get probability sample space and measurable events.

Key content and mathematical concept/construct: probability measure of chances in binary outcomes

Pebble-in-Fist Game: (Adopted from Mereku & Mereku, 2013)
This is a strategy game played in pairs with players facing each other. A player takes his or her hands to the back, hides a pebble in one hand and clenches both hands into fists. S/he brings the fists forward for the partner to guess and tap the fist containing the pebble. Finally, the fists are opened for the partner to verify if the guess was right. The player with the pebble wins when the partner‟s guess is wrong, otherwise the partner wins for a correct guess. A partner takes her/his turn of hiding the pebble until he or she wins else continues to do the guessing. The game in this case constitutes the major activity of the lesson. Children can be made to compare the results of Ata and Kuma in a *„pebble-in-fist game"* illustrated in the score sheet in Box 1. Scores are not very important for the purpose of the lesson, but serves as a source of motivation to the learners. Recording of results on a score sheet as in Box 1 is however an important mathematical process that the children must learn. It is necessary for the teacher to design an appropriate score sheet for children‟s use before the lesson

***Key content and mathematical concept/construct**:* The game make possible intuitive prediction of occurrence of events. Playing the *pebble-in-fist* game several times and comparing the results captured on score brings the concept of the probability fairness‟ and „chance‟.

Pebble-Picking Game:
This is a strategy game played by two, three or four players. Each player takes a turn in playing with five marbles. The player collects all the marbles into both hands and drops them on the floor. She selects one of the marbles and uses it to pick up others in the following way:
Students throw up the selected marble, pick another immediately on the floor with the same hand and catch the air-borne marble with it.
Students put the marble you have successfully picked with the selected marble aside and continue with the process until all the marbles are picked with the selected marble for the first round.
Student do the second round in the same manner as above, but this time, pick two marbles at a time (that is, picking two and then two).
In the third round a three and then a one are picked; and in the final round a four is picked at a go. At each stage, a player works out the combinations needed in order to pick the right number

Students then picks the entire five marbles at a goal to win.
A player fouls when he or she is unable to pick the right number or is unable to catch the air-borne marble with the marbles picked. The GAME moves on to the next player when a player commits a foul or successfully completes all the rounds.

Key content and mathematical concept/construct: A probability of success is computed based on success $P(A)$ or failure $P(A^c)$. The winner is the one who completes the tasks successfully with a total probability measure of $\sum_{i=1}^{n} P(A_i) = 1$. The pebble-picking game can be used as an activity to teach number facts in real numbers systems and also as a practice (or follow-up) activity. When the pebbles are replaced with numbered cubes the game brings to light problem-solving strategies on probability of each event a foul is committed or otherwise. Students draw table for success picking and failure picking with each measurable probability as follow:

$Number\ of\ pebbles$	$P(Success\ picking) = P(A)$	$P(Failure\ picking) = P(B)$	$P(A^c)$	$P(B^C)$
1				
2				
3				
4				
5				
$TOTALS$				

Let students compute the probabilities in the cooperate groups and drill then on additive and multiplicative probability measures.

Conclusion: summarize lesson through follow up questions and answer techniques on axioms of probability, it applications in formal and informal ethnomathematics.

Applications: Students would be able to use the knowledge gained to appreciate the mathematical measurability of events based on chances to make implication of indigenous games and activities that create chances and expectations found in their communities.

Evaluation: Students perform the following problem solving on plane geometry.

1. Two identical dies are rolled once, determine the sample space for this activity and find the probability that pair of the dies shows;
   i. Sum of pairs less than 10
   ii. Prime pairs
   iii. Even pairs
   iv. Factor pairs of 12 of sums of pairs more than 10
2. Given the following probabilities $P(A) = 0.39, P(B^c) = 0.045\ and\ P(C^c) = 0.33$. Find the following probability measures:
   i. $P(AUB)$ if A and B are mutually exclusive

ii. (AUB) *if A and B are independent*

$$P(AnBnC)$$

3. The probability that Agya Kwasi finishes planting his maize before it rains is $\frac{1}{6}$ and the probability that rodents destroy it is $\frac{3}{9}$. find the probability that
   i. The compliment of each events
   ii. he plants without rains and get rodents to destroy it.

Remarks:

DEMONSTRATION LESSON 5: TRIGNOMETRY ANGLE OF ELEVATION AND DEPRESSION

TRIGNOMETRY: Angle of Elevation and depression
SCHOOL: Experimental School A, B and C
CLASS: Experimental Group A
NUMBER ON ROLL: 67
AVERAGE AGE: 15+
TOPIC: Angle of Elevation and Depression

REFERENCE:

Allotey, G. & Buckwell, G. (2005). Macmillan Senior High School Mathematics for West Africa. (Book 1, 2 & 3)

Asiedu, P. (2011). Core Mathematics for West African Senior High Schools, *Akiola Publications Ltd.*

Bassett, D. R., Jr, Toth, L. P., LaMunion, S. R., & Crouter, S. E. (2017). Step Counting: A Review of Measurement Considerations and Health-Related Applications. *Sports medicine (Auckland, N.Z.)*, *47*(7), 1303–1315. doi:10.1007/s40279-016-0663-1

Fouze, A. O. & Amit, M. (2017). On the Importance of an Ethnomathematical Curriculum in Mathematics Education. *Eurasia Journal of Mathematics, Science and Technology Education*. 14(2): 561-567.

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Mathematics Association of Ghana (2009). Core Mathematics for Senior Schools Mathematics for West Africa (Books 1, 2 & 3)

Mereku, D. K., & Mereku, C. W. K., (2013). *Ghanaian case Study of Singing Games in Ethnomathematics*. Journal of African Culture and International Understanding. *6(1),16-23, Olusegun Obasanjo Library, Abeokuta, Nigeria.*

Statement of intent and Specific Objectives

Numeration concept is believed to be part of every culture so far as the mind conceived of body of numbers in counting for quantity. The topic seeks to introduce students into real number systems, the first scope of secondary core mathematics in the syllabus. Students are guided through ethnomathematics moves to establish interconnection between the formal number and numeration systems in relation to informal one existence among the Akans. We are to apply the conceptual framework behind number and numeration concepts from the formal curriculum to compare the informal ones. The lesson is guided by the following specific objectives. At the end of the lesson, it is expected of students to perform the following abilities:

Describe the place value concepts in natural base ten in the formal and informal structure in the number system (Knowledge)

Categorize real number systems into various compositions as rational and irrational, natural and counting, even and odd, prime and composite in finite and infinite form, (comprehension).

Operate on at least two binary number concepts through addition, subtraction, multiplication and division (Application)

express very large or small numbers in standard form as $(k \times 10^b)$. (Analysis)

distinguish formal numeration structure and informal numeration concepts, (synthesis/innovation/creativity)
review Akans numeration concept to connect with the formal structure of numbers based on place value(Evaluation).

Table 1: Formal curriculum structure and scope, ethnomathematical moves and mathematical concept formations.

S/n	Topic from the formal (school) curriculum	Curriculum structure for school level	Ethnomathematical moves	Mathematical Concept formation
6	Trigonometry	SHS 2 & 3	Indigenous building technology Measurement through foot and finger length Measurement of land for Farming Demarcation of plots and lands Games. Eg. Riding kite.	Distance apart, turnings as angles, traditional indigenous technologies. Eg. buildings

Teaching Resources: Flash cards of geometrical shapes, triangle, square, pentagon, circles, pictures, buildings

TEACHER-LEARNER ACTIVITIES
Introduction: Let students sing a traditional song with number recognitions and identify number and numerations as well as mathematical concepts the song lyrics presents. Example, *baako, mmienu, mmiensa, ne nnan; ne nyinaa kabom a 3y3 du* [i.e. one, two, three and four add up to make ten]

Key content and mathematical concept/construct: Recognition of numbers, number patterns, series and sequences, place values as well as concepts of addition.

Lesson Presentations
Guide students revise natural numbers, whole numbers and integers use the knowledge to explore the oral numeration of numbers from $1, 2, 3, \ldots, \infty$ by looking at it from formal structural systems to information presentation.

$$1, 2, 3, 4, 5, 6, 7, 8, 8, 10, 11, 12, \ldots, 20, 21, 22, \ldots, 30, 31, 32, \ldots, \infty.$$

Conclusion: summarize lesson by allowing students to compare the formal geometric representations to the informal traditional/indigenous application.

Applications: Students would be able to use the knowledge gained to appreciate the mathematical implication of indigenous technology found in their communities. They can measure, draw and find the dimensions of buildings and other material things found in their communities.

Evaluation: Students perform the following problem solving on plane geometry.
Agya Kwasi has a rectangular plot enclosed by angles $67^0, and\ 53^0$. Find the third angle enclosed by his plot of land.
Draw any four plane figures

Identify four traditional indigenous artifacts from your community that has geometrical applications of what you have drew.
Remarks:

DEMONSTRATION LESSON 6: VECTORS AND TRANSFORMATION

SCHEME OF LEARNING 7: MICRO-TEACHING ON ETHNOMATHEMATICS
SCHOOL: Experimental School A, B and C
CLASS: Experimental Group A
NUMBER ON ROLL: 67
AVERAGE AGE: 15+
TOPIC: Magnitude and direction of a vector quantity

REFERENCE:

Allotey, G. & Buckwell, G. (2005). Macmillan Senior High School Mathematics for West Africa. (Book 1, 2 & 3)

Asiedu, P. (2011). Core Mathematics for West African Senior High Schools, *Akiola Publications Ltd.*

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Statement of intent and Specific Objectives

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Describe the place value concepts in natural base ten in the formal and informal structure in the number system (Knowledge)
Categorize real number systems into various compositions as rational and irrational, natural and counting, even and odd, prime and composite in finite and infinite form, (comprehension).
Operate on at least two binary number concepts through addition, subtraction, multiplication and division (Application)
express very large or small numbers in standard form as $(k \times 10^b)$. (Analysis)

distinguish formal numeration structure and informal numeration concepts, (synthesis/innovation/creativity)
review Akans numeration concept to connect with the formal structure of numbers based on place value(Evaluation).

Table 1: Formal curriculum structure and scope, ethnomathematical moves and mathematical concept formations.

S/n	Topic from the formal (school) curriculum	Curriculum structure for school level	Ethnomathematical moves	Mathematical Concept formation
7	Vectors and Transformation in a Plane	SHS 2 & 3	Dancing Movements and turning about points games	Distance apart, turnings as angles, traditional indigenous technologies. Eg. Buildings, turning games

Teaching Resources: Flash cards of geometrical shapes, triangle, square, pentagon, circles, pictures, buildings

TEACHER-LEARNER ACTIVITIES
Introduction: Let students sing a traditional song with number recognitions and identify number and numerations as well as mathematical concepts the song lyrics presents. Example, *baako, mmienu, mmiensa, ne nnan; ne nyinaa kabom a 3y3 du* [i.e. one, two, three and four add up to make ten]

Key content and mathematical concept/construct: Recognition of numbers, number patterns, series and sequences, place values as well as concepts of addition.
Lesson Presentations
Guide students revise natural numbers, whole numbers and integers use the knowledge to explore the oral numeration of numbers from $1, 2, 3, \dots, \infty$ by looking at it from formal structural systems to information presentation.

$$1, 2, 3, 4, 5, 6, 7, 8, 8, 10, 11, 12, \dots, 20, 21, 22, \dots, 30, 31, 32, \dots, \infty.$$

Conclusion: summarize lesson by allowing students to compare the formal geometric representations to the informal traditional/indigenous application.

Applications: Students would be able to use the knowledge gained to appreciate the mathematical implication of indigenous technology found in their communities. They can measure, draw and find the dimensions of buildings and other material things found in their communities.

Evaluation: Students perform the following problem solving on plane geometry.
Agya Kwasi has a rectangular plot enclosed by angles $67^0, and\ 53^0$. Find the third angle enclosed by his plot of land.

Draw any four plane figures

Identify four traditional indigenous artifacts from your community that has geometrical applications of what you have drew.

Remarks:

DEMONSTRATION LESSON 7: PROBLEM SOLVING STRATEGIES

SCHEME OF LEARNING 5: MICRO-TEACHING ON ETHNOMATHEMATICS
WORDS PROBLEM SOLVING: Problem Solving Strategies
SCHOOL: Experimental School A, B and C
CLASS: Experimental Group A
NUMBER ON ROLL: 67
AVERAGE AGE: 15+
TOPIC: Words Problem Solving

REFERENCE:

Allotey, G. & Buckwell, G. (2005). Macmillan Senior High School Mathematics for West Africa. (Book 1, 2 & 3)

Asiedu, P. (2011). Core Mathematics for West African Senior High Schools, *Akiola Publications Ltd.*

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Statement of intent and Specific Objectives

Numeration concept is believed to be part of every culture so far as the mind conceived of body of numbers in counting for quantity. The topic seeks to introduce students into real number systems, the first scope of secondary core mathematics in the syllabus. Students are guided through ethnomathematics moves to establish interconnection between the formal number and numeration systems in relation to informal one existence among the Akans. We are to apply the conceptual framework behind number and numeration concepts from the formal curriculum to compare the informal ones. The lesson is guided by the following specific objectives. At the end of the lesson, it is expected of students to perform the following abilities:

Describe the place value concepts in natural base ten in the formal and informal structure in the number system (Knowledge)

Categorize real number systems into various compositions as rational and irrational, natural and counting, even and odd, prime and composite in finite and infinite form, (comprehension).

Operate on at least two binary number concepts through addition, subtraction, multiplication and division (Application)

express very large or small numbers in standard form as $(k \times 10^b)$. (Analysis)

distinguish formal numeration structure and informal numeration concepts, (synthesis/innovation/creativity)
review Akans numeration concept to connect with the formal structure of numbers based on place value(Evaluation).

Table 1: Formal curriculum structure and scope, ethnomathematical moves and mathematical concept formations.

S/n	Topic from the formal (school) curriculum	Curriculum structure for school level	Ethnomathematical moves	Mathematical Concept formation
8	Words Problem solving	SHS 1, 2 & 3	Storytelling Riddles Puzzles Role-playing	General primary and secondary mathematics concepts

Among these mathematical concepts, ethnomathematical moves done by children and adopted from the cultural perspective to support understanding may include finger counting, traditional

Teaching Resources: Flash cards of geometrical shapes, triangle, square, pentagon, circles, pictures, buildings

TEACHER-LEARNER ACTIVITIES

Introduction: Let students sing a traditional song with number recognitions and identify number and numerations as well as mathematical concepts the song lyrics presents. Example, *baako, mmienu, mmiensa, ne nnan; ne nyinaa kabom a 3y3 du* [i.e. one, two, three and four add up to make ten]

Key content and mathematical concept/construct: Recognition of numbers, number patterns, series and sequences, place values as well as concepts of addition.

Lesson Presentations

Guide students to use Polyas problem solving model to solve related words problems in Algebra, equations and other related topics.

Key content and mathematical concept/construct: Recognition of basic generics skills: reading, writing, speaking, problem solving skills based on Polya"s and J. Mason"s model

Guide students to construct a formula for a given mathematical task. E.g. Aku has *y* cedis more than Baku, if Baku has *x* cedis, then Aku has (x + y) cedis, adapted from MOE (2010) core mathematics syllabus pg 15

Key content and mathematical concept/construct: Recognition of basic generics skills: reading, writing, speaking, problem solving skills based on Polya"s and J. Mason"s model

Construct a formula for a given mathematical task, E.g. Aku has y mangoes more than Baku. If Baku has x mangoes, how many do they have altogether? MOE, (2010) syllabus pg 15

Key content and mathematical concept/construct: Recognition of basic generics skills: reading, writing, speaking, problem solving skills based on Polya"s and J. Mason"s model

Let students work in their cooperate group to solve selected words problem from Akiola (2011) text book for West African Senior High Schools Pg (113-115) and other selected past question problems from WEAC.
Key content and mathematical concept/construct: Further problem solving strategies.

Folktales;
The use of Folktales can even support the teaching of some mathematical words problem, Fouze and Amit, (2017). Socio-cultural values, traditions, and symbols are demonstrated in the social life of every group of people. Education in general and mathematical education, in particular, is also affected by cultural values. The integration of Folk-stories adapted from traditional folktales systems according to Fouze and Amit, (2017) helps bring students understanding of words problem. An Example of a Folk Story that Contains Mathematical Values and that can be used to Aid the Instruction of Mathematics (adapted from Fouze and Amit, 2017) is given below:

"On Ananse"s birthday, his grandmother cut 12 pieces of cake, after he told him that he had invited twelve friends. However, only two friends arrived on time, and the rest came later".
Question: if Ananse wishes to divide the 12 pieces of cake between his son Ntinkumah and himself, how many pieces of cake would each receive?
Question: If we had 16 pieces of cake and four boys, can we divide them equally between them?
Question: As we have six friends and 12 pieces of cake, how many pieces does each child receive?

To bridge the gap between cultural-based mathematics and formal mathematics, there is the need to mathematicised cultural-based mathematics using problem solving strategies suggested by the school curriculum.

Conclusion: summarize lesson by allowing students to solve more words problem involving algebra to the informal traditional/indigenous application.

Applications: Students would be able to use the knowledge gained to appreciate the mathematical implication of folktale heard from their communities that can riddle mathematical problem solving in ethnomathematics.

Evaluation: Students perform the following problem solving on plane geometry.
"On Ananse"s birthday, his grandmother cut 12 pieces of cake, after he told him that he had invited twelve friends. However, only two friends arrived on time, and the rest came later".

Question: if Ananse wishes to divide the 12 pieces of cake between his son Ntinkumah and himself, how many pieces of cake would each receive?
Question: If we had 16 pieces of cake and four boys, can we divide them equally between them?
Question: As we have six friends and 12 pieces of cake, how many pieces does each child receive?

Remarks: