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The Interconnections of Akan Informal Ethnomathematics and School-based Formal Curriculum Mathematics

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Abstract

The focal point of this study lies in the intersection between the formal curriculum structure of school mathematics, commonly aligned with Western ideals, and the informal ethnomathematics prevalent within the Akan community of Ghana. The curriculum implementation process is a central mandate for every schoolteacher, shaping the educational landscape. The formal system of school mathematics adheres to a distinct curriculum framework, often characterized by Western educational standards. However, this study explores the interconnectedness between this formal curriculum and the informal ethnomathematical practices embedded within Akan culture. The research aims to elucidate how Akan ethnomathematics can inform and enrich the formal school-based mathematics curriculum implementation by examining the interface between these two realms. Through this exploration, the study explores novel approaches to curriculum design and implementation, fostering a more inclusive and culturally responsive educational environment.

Keywords: Academic Performance, Entering Characteristics, School Background, School Placement, Student Background

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Introduction

Every school is situated in a cultural environment. The socio-cultural perspective in doing school mathematics revolves around how people perceive 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 on intuition, abstractions, and contractions. Mathematics, with its most abstract and robust theoretical systems, is linked to the scientific process of nature explorations through the eyes of the ethnomathematics approach as a tool for cultural evaluation and social representativeness (Silva et al., 2022).

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 are 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, is paramount to researchers (Owens, 2017).

As suggested by NaCCA (2019, p. 8) in the curriculum implementation process, the current nature of school Mathematics 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 conversationally Westernized, Eurocentric, and whitish, with little application to the learner's cultural identity (Mereku, 2013). Basic Ghanaian ethnomathematics exists that can support the teaching and learning of school mathematics in various forms, connecting informal and formal mathematization processes. Figure 1 shows some basic ethnomathematics connecting concepts of measurement, capacity, geometric games, and tallying.

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 conversational method of teaching mathematics is Westernized, Eurocentric, and whitish (Owusu-Darko et al., 2022). Content-based knowledge in mathematics curriculum implementation interests all stakeholders of the learner in every school. Teachers strive 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 mathematics learning meaningful, ethnomathematics is an emerging teaching philosophy with a naturalistic view that can help children from multicultural settings 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 in 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 no exception.

Literature Review

Ethnomathematics can be synthesized to denote a historiographical connotation for informal cultural mathematics. 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 "the politics of (Ethno) mathematics education (Oliveras, 2000). The cultural dynamics of the encounters try to figure out the mathematical, conceptual framework of which it has progressively evolved to be like this current trend. Reconciling school mathematics with informal ethnomathematics is a concern of most researchers nowadays. The connection between cultural diversity and subject-based concept teaching has been explored (Orey & Rosa, 2016; Rosa et al., 2017). A focus on making a connection to the curriculum adaptation has little concern. However, culture has now informed educators of the need to consider cultural diversities in designing teaching methodologies.

Rosa (2016) defines 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 what we already know and 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).

Researchers see Ethnomathematics in different allusions that they best see. Concerning the field of mathematics, and in line with Bishop (2002), considering mathematics as human and cultural knowledge, there appears to be a change in the meaning of ethnomathematics as diversity within mathematics and 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 revealing the diversity of mathematical practices but also emphasizing the complexity of each system. Thus, ethnomathematics describes the different mathematical practices that have their bases concerning cultural diversity.

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

Many ethnomathematics today started as teachers who became enthusiastic about finding 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 in 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 ICME 3 was organized through survey papers that reported the perceptions of mathematics educators worldwide 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).

Ethnographical View on Numeration and Number

An investigation by Supiyati, Hanum, and Jailani (2019) drew on results from psychology and cultural and linguistic studies and argued 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 numbers (number) 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 placed that in the context of related cultural issues, including verbal and symbolic representations of numbers. Thirdly and more pragmatically, they offered teaching strategies that seem helpful in developing quantity sense coupled with number sense. They finally discovered that there is a moral imperative to connect number sense with such a quantity sense that allows students to feel the weight of numbers. Learners must develop a feeling for numbers, which includes a sense of what numbers are and what they can do (Hardegree, 2003).

Ethnomathematics Implications

The ethnomathematical study has helped suggest a more learner-friendly approach to studying mathematics. Mathematical concepts under various generalization and modeling approaches in the formal systems make it challenging to mix school mathematics and ethnomathematics (Rosa, 2000; Rosa & Orey, 2003). Learners' practice of academic mathematics, herein referred to as a formal mathematical education system, learn to model situations that 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 students are encouraged to solve problems that are related to their communities. Mathematical modeling acts as a conduit linking ethnomathematics and Western-academic mathematics that are essential for the student's academic achievement in today's globalized 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 the 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 beds, houses (round and rectangular), decorations, baskets, local drums, and fish traps (Abonyi, 2015). There is a 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 that 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 canvassed on how to assist students in developing a positive attitude toward the study of mathematics so that they can perform well in the subject. In this directive, Bean et al. (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.

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, generally, 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. Orey 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 objectives related to passing standardized exams that conform to traditional school mathematics systems (Rosa, 2000). Stakeholders, including teachers, management, and educators, sense that their students will not take mathematics content learning seriously if they use an ethnomathematical approach in school curricula. There is the belief that mathematics idealization makes students and teachers accountable in standardized examinations. This has created an extreme problem of considering ethnomathematics as a waste of students' and teachers' time in meeting the WASCE requirement (Clark & Napp, 2013). The West African Examination Council (WASSCE) often tries to assess students' application of mathematical content by merging application to ethnomathematics (see fig 4.8, SSSCE 2009 past question).

Formal Mathematics Curriculum Structure: The School Curriculum

The curriculum is all the experiences a learner acquires from the school system or any organization. However, the school curriculum is structured to conform to some formal and standardized 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 recognizing and applying appropriate mathematical problem-solving strategies" (CRRD, 2010, p. 2). The "daily life" issue is connected to the student's interaction with their adaptive cultural environment, which ethnomathematics should address.

Different meanings of the conceptual definitions of the curriculum have been considered over some time, with authorities still deciding what the term means (Fouze & Amit, 2018). While some curriculum consultants have limited this to the realm of academic pursuit only, others have argued with the nonacademic meaning of the term curriculum. Can we consider our informal, traditional type of education as curriculum-based? The conventional informal curriculum may be seen as unwritten and subject to oral transmission. Booker (2009) put the curriculum into three perspectives: 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 its various syllabuses to be used by schools under her jurisdiction. The implement aspect is the one few teacher use in classes. According to Traverse et al., the attained part of the syllabus 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 a need for mathematics educators to play their part well by considering its implementation along with ethnomathematics pedagogies.

According to Mereku (2013), Ghanaian official school mathematics curriculum comprises textbooks, teachers' handbooks, and syllabi. This listed curriculum component has a widespread impact on classroom practice in Ghana; to him, even few teachers have access to it. An investigation done to find 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 these Ghanaian curriculum implementers, it can be linked to the ethnomathematics approach to induce learners' understanding. Perhaps this could help realize the third general objective 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 and Mereku (2016)

Suggestive Way of Merging Ethnomathematics to School Formal Systems

From an informal perspective, the ethnomathematical study needs to be reconciled with the conventional Eurocentric formal education systems. The curriculum structure and mathematics educators' effort in implementing it need to adhere to the 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. They can realize this by formulating the hypotheses surrounding the ideal concept we need to mathematicize. We can also classify social data and traditional mathematics systems to conform to the bases of pure mathematics systems from Western mathematics idealization. Some of the information from a sociocultural perspective can be important and non-important to the hypotheses binding the merge of the curriculum. Selection of essential variables, symbols, materials, and artifacts adapted from a cultural description of those relationships in mathematical terms can be linked to serve an exampling base for topical issues in the formal mathematical concepts thought (Orey et al., 2006).

Ozofor and Onos (2018) experimented with using the ethnomathematics methodology in teaching some selected topics, including probability, in some senior grade levels. The ethnomathematics approach used affected students' academic achievement more positively than the conventional technique used in teaching another controlled group in selected topics at the senior grade level. It enhanced and facilitated higher and better performance in mathematics. We believe that students will appreciate it better when we embed a similar approach in teaching the suggested scope of topics specified by the school syllabus. Ozofor et al. (2018) experimental study on the use of ethnomathematics to teach control and experimental groups also revealed that gender did not affect the ethnomathematics method so far as teaching and learning are concerned. Students' performance achievement is not biased toward the use of the ethnomathematics approach. Again, the findings revealed that ethnomathematics was more operative in nurturing and motivating learners' interest in the lesson 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 a method is rooted in British culture, allowing students to learn by rote memorization. The conflict between culturally known problems (ethnomathematics) and unknown problems of the learners (Eurocentric approach) throws confusion in their minds as they struggle to comprehend mathematical concepts. This gives little or no room for the practical aspects of a student's life as the curriculum aims to achieve. The method of teaching and learning mathematics in the African context is echoed by several mathematics educators who have the ethnomathematics naturalistic ideology (Eshewari, 2009; Fasheh, 2002; Obodo, 2008; Fouze & Amit, 2017).).

To end the poor performance and students' interest in mathematics, the Chief examiner report of the West African Examination Council (WAEC, 2007) has recommended that mathematics teaching methods should be practical, applicable, and project-oriented (Obodo, 2008). Even though the ethnomathematics approach is silent in the suggestion, the essence of making mathematics lessons practical still boils down to letting the learners explore their environment. The discovery approach to the teaching of mathematics as against teachers' dominant choice of the Expository method, as investigated by (Mereku, 2016), can adapt the ethnomathematical approach to guide teachers' choice of 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 formalization, computer-aided instruction, and problem-solving methods (Harbor-Peter, 2000). We propose a connection between these methods and ethnomathematics to develop learners' interest and understanding of the mathematics we teach.

Specific Objectives

The study has the following specific objectives:

1. To explore Akan's basic ethnomathematics activities to support teaching secondary school mathematics.
2. To investigate whether there exist interconnections between school formal mathematics and Akan basic informal ethnomathematics.

Methods

The study adopted a qualitative approach to data collection, analyses, and interpretation of Akan cultural mathematical elements and concepts with existing Ghanaian formal school mathematics. Akan community is a major tribal community in Ghana, West Africa. The study considered the non-written mathematics known and understood by the Akan's as informal, and the westernized exemplified school mathematics as formal. Akan Basic Ethnomathematical Activities were surveyed by selected 86 students from two secondary school classes. There was some selection of School-based mathematics standard concepts from the formal curriculum (school mathematics teaching syllabus) used in Ghana for teaching mathematics. The sampling was done using a convenience survey of students and schools situated in the Akan community.

The counting ethnomathematics, numeration systems, geometry, and algebraic concepts from informal and formal mathematical systems were examined. The study adopted content and context analyses of these informal and formal mathematics from Akan culture and school curriculums, respectively for the analyses.

Results and Discussions

This study reports a survey on Akan ethnomathematics concepts and their interconnection with the formal school-based curriculum in the teaching and learning process. A report reports how informal Akan ethnomathematics is seen from tradition and arbitrary mathematics connotations as a basis for teaching formal mathematics systems. The data analyzed constituted field observations of Akan artifacts, ethno-technology, and, on some occasions, interview guides for study participants.

School Mathematics Organizations and Some Akan Ethnomathematics Activities

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

For instance, the Ghanaian Senior High School syllabus structure is organized within the first three years with these strands. The researcher conducted a content analysis on the syllabus to determine how basic ethnomathematics activities support the development of mathematical concepts in the school mathematics curriculum. Table 1 shows the strands (contents) from the formal SHS mathematics curriculum, the level to be taught, and links to basic ethnomathematical activities that support the teaching of school mathematical concept formation for the respective standards.

Table1. School Mathematical Standards and Akan Basic Supportive Ethnomathematics

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	Translation, Bearings, rotation, enlargement, reflection, similarities

			5. length	
8	Problem Solving	SHS 1, 2 & 3	1. Storytelling 2. Riddles and Puzzles 3. Role-playing	Recreational mathematics

Table 1 shows an interconnection of basic Akan ethnomathematics activities is 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, and naming techniques.

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 estimate lengths, distances, and perimeters of surfaces arbitrarily. Other practices, such as measuring land for farming, demarcating plots and lands, and measuring height and distance, are practiced, connoting their knowledge of geometrical applications.

The concepts of area, perimeter, and volumes are learned 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 the area and perimeter of a plot of land. Ethno-technology of home-based artifacts supports the recognition of volumes of pots in their various shapes and forms to connote capacity. The construction of indigenous circular technology like earth-ware bowls suggests 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 various indigenous African ethnomathematics to revolve around the application to geometry. The Akan ethnomathematics has a lot of equal geometrical applications of formal mathematics systems. Algebra is also structured to be taught in SHS 1 and 2. The concepts of set and logic are found in Akan concepts of market sales, riddles, and puzzles, and games such as drafting to make deep abstractions in logical reasoning.

The teaching of Statistics and Probability is to recognize the need for data collection, analyses, and estimation of chances of occurrence of events (NaCCA, 2019). The topic of probability and statistics is organized to be taught in SHS 2 and 3. Some Akan ethnomathematical practices to recognize this involve 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, and Peele are designed to help build children's and adults' ways of thinking and the chance of winning or losing. The body of numbers and the possibility of occurrence of events are seen to have a standard 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's 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 are to be taught in SHS 2 and 3. Akan adopts dancing moves and skills to show the translation of gestures, such as Akan adowa dance. Vectors and bearings help learners recognize translation, turning about points, bearings, rotation, enlargement, reflection, and identifying similarities. Problem-solving strategies are designed for all the topics to help learners reflect on their problem-solving thinking skills in applying and evaluating mathematical concepts for all levels of the child's education. Akan uses storytelling, riddles, puzzles, and Role-playing as a form of Recreational mathematics.

To further establish the interconnection between Akan basic ethnomathematics activities with formal school mathematics, students were asked to associate their understanding of certain formal mathematical concepts to some Akan ethnomathematics surveyed. Table 2 shows students' responses to whether they recognize the interconnections between selected basic Akan ethnomathematics and school-based mathematical concepts or not. The number and corresponding response percentage (yes or no) are organized in Table 2.

Table 2. Students' response to whether teachers interconnect 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 formal school mathematics is explored from field observation, and content analyses is made. Students' response to yes or otherwise is given in Table 2.

The Akan referred to the concept of numbers 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 %, while 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, and 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 responses to this recognition of the interconnection were 67 (77.9%) and 19 (22.1%), respectively.

The concept of set is seen from the Akan ethnomathematics perspective as (aboaboa, boa) for the act of grouping things together in their unique likeness. The set helps in logical reasoning. Students' yes and no responses 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) help to connote algebraic concepts of thinking in abstractness. Students with yes and no responses to this recognition of the interconnection were 26 (30.2%) and 60 (69.8%), respectively.

Akans typically use geometric-based games to entertain and help children recognize shapes, sizes, angles, geometry, polygons, area, and perimeters. Students who realized the interconnection with a valid yes response were 54 (62.8%) as opposed to those with an invalid no response 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' with yes and no responses to this recognition of the interconnection were 58 (67.4%) and 28 (32.6%), correspondingly. Geometrical artifacts 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 sometimes area measurement. The number of students with yes and no responses to this recognition of the interconnection was 54 (62.8%) and 32 (37.2%), respectively.

Akan's popular kitchen dish bowl called Asanka and its various forms have an accurate estimation of the concept of pi (\pi) measured from circular ethno-technology. This is deemed to support the teaching and learning of mensuration topics. Students with yes and no responses to this recognition of the interconnection were 16 (18.6%) and 70 (81.4%). Foot and Hand counting techniques are essential ethnomathematics activities used to measure perimeter and area. Students' yes and no responses to this recognition of the interconnection were 45 (52.3 %) and 41 (47.7%), respectively.

In conclusion, making a connection between ethnomathematics and school mathematics is understood by the majority of the students. Mathematics educators who connect ethnomathematics with school mathematics typically help students understand the formal application of school mathematics.

Akan Number Concepts, Numerations, and Counting System with Formal School Math

Akan concept of number recognition is predominantly based on Language spoken and transmitted orally. Language is indispensable communication for human existence, too. The bases of language communication dissociate man from other living organisms on the earth's surface. Communication of thought brings out the cognitive ideas inherent in human knowledge. Akan's communication system and education systems are predominantly based on oral traditions. For instance, the preservation of number concepts tells a lot about the extent to which Akans knew mathematics before the arrival of the white man's educational system, which was called formal education (Shapiro, 2001). In this section, we investigate the extent to which the Akan language system, in the form of their communications, suggests their knowledge of ethnomathematics of the number concept.

Number and numeration are the introductory topics (strand) at almost all levels of pre-tertiary education. The idea of a counting system among the Akan people suggests the natural base ten algorithms. The researcher found that the concept of counting system and numerals are explained while asking questions to different Akan people. The Akan people mostly use their native counting system (which has been in practice for an extended period of time) called nkontabudeƐ (numerals). The researcher observed that there is no written record of the Akan concept of numbers and numerations. Such mathematical ideas and conceptualization were transmitted through oral tradition before they were enlightened into formal education systems. The Akan informal ethnomathematics numeration concepts are counted based on a place-value of ten, i.e., ones, tens, hundreds, thousands and tens of thousands, hundreds of thousands, and millions up to any finite or infinite move of counting systems seen from the formal types, i.e.

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

If knowledge of formal systems 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 the initial digit place value. Tens denotes edu. After ten counts, the place value is felt in additional 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 3, 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 3, where a comparison of the formal numeration place value structure to the Akan informal illustrations is given.

Table 3. 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 3, the Akan language system in the numeration part of speech represents their knowledge of mathematics through oral counting. Any number representation of the Hindu-Arabic formal representation was seen to be equally represented in the Akan informal numeration. The counting system seen in Table 3 sequences an infinite count of numeration to match the place value system illustrated in Table 3. The student interview below shows Akan people's counting system knowledge of numbers reading, speaking, and writing based 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.

The responses given by the interviewee were splendidly given. Several opinions were sought by ten (10) interviewees who gave equally good responses for their knowledge of Akan numeration concepts. Few interviewees flopped in their understanding of numeration recognition from the Akan perspective. Others also mixed their responses in Akan ethnomathematics on numeration with the formal one. Many 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 stands for the uniqueness of a million representations. Some respondents misuse it and say, ɔpepepeepee to in billion connotations. Every ɔpe stands for a million, the next ɔpe (ɔpe-pe) extends to a billion, the next ɔpe (ɔpe-pe-pe) further extends 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 a few numerical samples for the few students' opinions on their knowledge of Akan ethnomathematics in Table 4. A comparison response for the Akan numeration concept is compared with the numeration of the formal way of mentioning the Hindu-Arabic numerals.

It is noted that the generic numerical representation of the 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 indicated in any form was dictated by the cultural reformation of the ethnic group of people who needed arithmetic education (Mosimege, 2017;

Muzdalipah & Yulianto, 2018).

Table 4. Comparison of Formal and Informal Numeral Identification

Hindu-Arabic Numerals 678	**Formal numeration** Six Hundred and seventy-eight	**Informal Akan numeration** 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.

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 teaching 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 sequence members is a constant. An example is the natural counting of numbers;

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

A limitation of Akan ethnomathematics is the inability to express numbers and numerations in formal symbol terms and structures. The number system is read orally and transmitted in oral tradition forms. Should there have been identified a more formal illustration representing 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.

Akan Ethnomathematics on Measurement of Length and Distance

The Akan people have peculiar means of recognizing arbitral measurements of length and distances for small, medium, and large dimensions. The SI unit is deemed appropriate for the formal classroom curriculum implementation in the formal system. Area and relationships among area units is another mathematical practice observed in the agricultural setting of most Akan communities concerning conversion, comparison, and arbitral measurement of length and area. Table 5 shows how the Akans demonstrate arbitrary length measurement with western unit interconnections.

Table 5. Comparison of Formal and Informal Numeral Identification

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 5 presents indigenous units of the area in Akan people. As Table 5 presents, the people of Akans use different indigenous units for area measurement in agricultural settings. In this regard, the study investigated the nsatea (the thickness of the middle figure), which denotes one figure's length of about 2.5cm. Similarly, more excellent dimensions of length measured in kilometers and hectares are seen as kwansin and kwantenten.

Set Ethnomathematics Illustrations

Akan people recognize their knowledge in the set. The concept of sets is referred to as akuokuo, aboaboa, or mmoanoo. Figure 1 shows set recognition from market scenes where things are organized for sales in their unique likeness, grouping forms, and sales mapping in their various forms.

Figure 1. Akan Market Scene with Set Concept Ethnomathematics

Akans recognize set as the mathematical application to collect different things organized in a common likeness, as seen in Figure 1. The grouping of objects for sales contains elements or members such as vegetables (onions, green papers, tomatoes, and others), various forms of fish, and foodstuffs (cassava, cocoyam, plantain, and others). The association of these concepts can be grouping mathematical objects of any kind, such as numbers, symbols, points in space, lines, other geometrical shapes, variables, or even objects listed in their similarities and likeness.

Table 6 shows set recognition from formal listing and informal listing forms organized by students in class activities by recognizing set statement, set listing, and set builder notation forms, respectively.

Table 6. Comparison of Formal and Informal Numeral Identification

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 in Table 6 and Figure 1, respectively. They believe 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 sale are grouped into similar items showing set representations. Students were drilled to list set definitions using Akan numeration concepts, as illustrated in Table 6.

Some Akan Ethnomathematics Activities Supporting the Teaching of Algebra

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

Table 7 shows how Akan ethnomathematics recognizes the concept of algebra abstraction. Students made connections to link the formal way of connoting an unknown variable to abstractness.

Table 7. 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 are also orally expressed to connote their mathematical discourse, as seen in Table 7. The concept of a variable x means biribi. The percentage of x is expressed as ebi (x%). The concept of all also represents 100%. The concept of limits and infinity is seen as akyirikyiri nohoaa. Akan uses the discourse nkabom, ntefirimu, mmohoo-mmohoo, and nkyekyemu to show the sum (+), difference (-), multiplication (\times), 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 in this regard is to bring the essence of creativity, citizenship, exploration, and pedagogical strands that would enhance the teaching and learning of mathematics. Today's mathematics educators have lost sight of being innovative and still admit to the old intransitive approach of materializing mathematical content and problem stratification. For example, you would sample textbooks from a community in Bolga or Yendi or any of the northern tribes of Ghana only to see and read about word problems in mathematical topics where strange Akan names or perhaps Western names are used to exemplify the word problems.

Activity Students were Asked to Analyze 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 analyze the word problems from activity 3. This was to investigate their difficulty level and examine what caused their difficulty. Students attributed the difficulty associated with the problem investigation to hostile choice of words, especially from activity 3, with respect to unfamiliarity with the 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. Problems 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, and 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 an unfamiliar delicacy, Pizza, suppergetty, and cheese, as well as an unfamiliar currency not so much adapted to their African Ghanaian environment or culture, might drag their understanding down. This hinders their understanding level of the question. Using the most familiar names from their land of birth and the culture they know will help facilitate the level of understanding.

Most Ghanaian core mathematics books surveyed from across the regions use the most popular books deemed appropriate to help them pass the West African Secondary Certificate Examination (WASCE). On the contrary, the ideal ethnomathematics application needs to catch up. A survey in the Core mathematics teaching syllabus, MOE (2020) has this mathematical problem as an activity:

a. TLA: Guide students to construct a formula for a given mathematical task. For Aku has *y* cedis more than Baku; if Baku has *x* cedis, then Aku has (x + y) cedis [adapted from MOE (2020) core mathematics syllabus page 15]
b. Construct a formula for a given mathematical task, e.g., Aku has more mangoes than Baku. If Baku has x mangoes, how many do they have altogether? [MOE, (2020) syllabus page 15] Narulita et al. (2019)

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

Geometric-Based Game Illustrations

Culture and Geometry are interconnected, making school geometry closely related to the environment and 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 that have been adapted to suit the child's environment. A lot of ethnomathematics has been researched, basically concerning geometry and mensuration. Using existing artifacts, we can establish ethnomathematics geometry as a linkage to formal mathematical concepts.

Some Akan ethnomathematics games illustrate their knowledge of geometry and mensuration. The Peele game (sometimes called kantalae, deduced from probably contour lines and other different names) is played based on the knowledge and application of the Akan concept of geometry. The game is drawn on the ground with traces of geometrical shapes such as squares and rectangles with an ending circle. Recognition is given to stepping on a line segment of the geometrical shape as the basis of losing to an opponent. The Figure 2 is the layout of the Akan peele game performed by both male and female children.

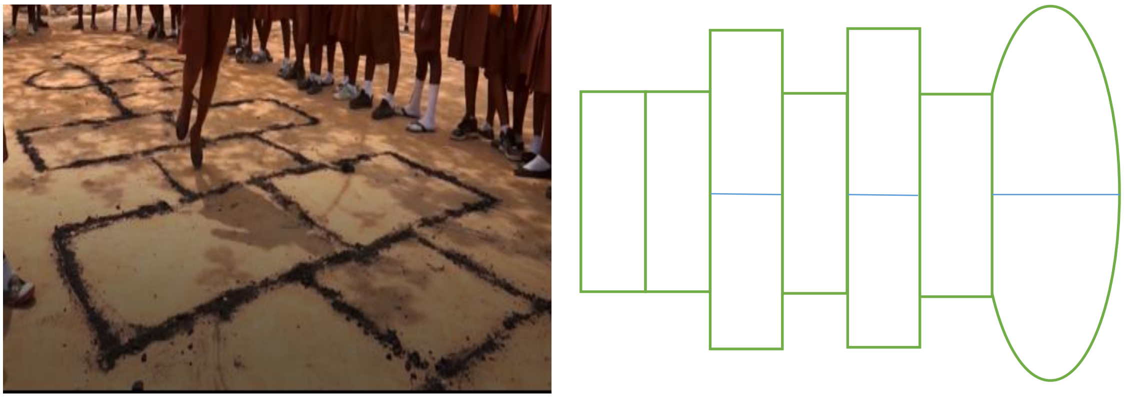

Figure 2. The Akan Peele Game shows geometric knowledge and applications

As seen in Figure 2, the game is played with forward and backward movements by limping through the various geometrical plane shapes. Stepping on the line segments denounces a foul played, giving the other opponent the chance to step in and play equally. Able to go through the spaces of the geometrical shapes allows 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 can step into that plot except himself or herself. The game could be played by mixed gender.

Student outlined the game on paper and labeled the joints A, B, C, …, and U, as seen in Figure 2. They found the total surface area and perimeter of the layout of the Peele game.

Conclusion

Most 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 spaces, constructed with clear area, volume, and perimeter distinctions for peculiar purposes. These can serve as a 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 needs to be a written record of the Akan concept of numbers and numerations and the mathematical skills used in their ethnic-technology. Such mathematical ideas and conceptualization were transmitted through oral tradition before they were enlightened into formal education systems. The Akan numeration and counting system possesses a base ten place value concept. For example, edu (tens), ɔha (hundredths), Apem (thousandths), and the ɔpe stands for the uniqueness of a million representation. Some respondents misuse it and say ɔpe (ɔpe-pe-pe) to represent a billion connotations. The Akan ethnomathematics is richer in various number generic representations to illustrate fractions, ratios, and proportions termed nkyekyemu.

Games and artifacts are on the doorsteps of every Akan child. They craft and play with them with particular mathematical concepts. Making it part of the curriculum would build their self-esteem and cultural identity. The mathematics teaching would be meaningful when explored further in the curriculum implementation process.

The Akan ethnomathematics is seen in various traditions and cultures of the people. This existed since time immemorial. Akan ethnomathematics exist in different forms. Akan language forms possess a rich number and numeracy called nkontabudeƐ as their language describes. The Akan ethnomathematics activities support the new and old syllabus mathematical themes, areas, and strands in the form of numbers, algebra, geometry and measurement, data mensuration, and others.

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 for most teachers. The mathematics curriculum's broad structure and scope are closely connected to 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.

Recommendations

Based on the findings, the study recommends that authors of mathematics books consider exemplifying mathematics problem structure to connote the ethnomathematics of the communities in which the school is situated. Students should uphold the ethnomathematics approach to teaching if teachers adopt this. It has been found that this approach to education enhances students' interests and motivation. This makes lessons friendly to learners and links them to their relevant previous knowledge, which conforms to the educational axioms of teaching.

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 teach school mathematics. They need to be trained in integrating ethnomathematics into the formal teaching of school mathematics.

Ethnomathematics, which has mathematical implications for culture, must be extended to other multicultural settings in all Ghanaian communities. This would build our perceptual understanding of the usefulness and effectiveness of ethnomathematics and its implications for mathematics education in Ghana.

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Author Contribution : KDP, SES, OAS: Conceptualization, Writing - Original Draft, Editing and Visualization;

KDP, SES, OAS: Writing - Review & Editing, Formal analysis, and Methodology Validation and Supervision

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