**Journal of Mathematics and Science Teacher**
2023, 3(2), em042
e-ISSN: 2752-6054
https://www.mathsciteacher.com/

MODESTUM

**Research Article** **OPEN ACCESS**

# Akan ethnomathematics: Demonstrating its pedagogical action on the teaching and learning of mensuration and geometry

Isaac Owusu-Darko [1*], Rufai Sabtiwu [1], Florence Doe [2], Belinda Owusu-Mintah [3], Ernest K. Ofosu [3]

[1] Valley View University, Techiman Campus, P. O. Box 183, Techiman, GHANA
[2] University of Education, Winneba, Box 25, Winneba, GHANA
[3] SDA College of Education, P. O. Box 18, Asokore-Koforidua, GHANA
***Corresponding Author:** iowusudarko@vvu.edu.gh

**Citation:** Owusu-Darko, I., Sabtiwu, R., Doe, F., Owusu-Mintah, B., & Ofosu, E.K. (2023). Akan ethnomathematics: Demonstrating its pedagogical action on the teaching and learning of mensuration and geometry. *Journal of Mathematics and Science Teacher, 3*(2), em042. https://doi.org/10.29333/mathsciteacher/13281

**ARTICLE INFO**

Received: 17 Sep. 2021

Accepted: 11 Nov. 2022

**ABSTRACT**

The mathematics curriculum implementation depends largely on teachers' choice of pedagogical skills that would influence meaningful teaching and learning. The suggestive ideal approach this paper presents is to consider exploration and demonstration of Akan (a tribe in Ghana, West Africa) ethnomathematics in the teaching and learning of some selected mensuration and geometrical concepts found in the secondary school curriculum. The study found various Akan ethnomathematical processes supporting the teaching and learning of school geometrical and mensuration topics such as artefacts, buildings, tools, and others. The ethnomathematical processes reveal a resemblance of *pi* ($\pi$) concepts and its application to ethno-technology from selected artefacts used for pedagogical demonstrations. We recommend further research into the practical effect of ethnomathematics move in teaching other mathematical concepts in several communities where there exists cultural diversity. It is suggested that mathematics educators adopt ethnomathematics methodology by integrating it into the curriculum implementation process to check its impact on the teaching and learning of mathematics.

**Keywords:** ethnomathematics, pedagogy, curriculum implementation, pedagogical moves, informal teaching, geometry, ethno-technology

## INTRODUCTION

Culture and indigenous application to geometry and mensuration are interconnected, making school formal content 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 (Acharya, 2019; Unodiaku, 2018; Zirebwa, 2008). The teaching and learning of mensuration and geometry has been a problem to most students especially in Ghana.

Ethnomathematics philosophers in the past decades has shown interest towards finding the most prudent way to facilitate Mathematics teaching and learning from cultural perspective (D'Ambrosio, 1985; D'Ambrosio & Rosa, 2017; Davis & Seah, 2016; Kusuma et al., 2019; Machaba, 2018; Sunzuma & Maharaj, 2019). This has been the concern of not only government but also general stakeholders who have child education at heart. Researchers investigate a lot on how to make the mathematics education learning friendly and teaching pleasant.

A new way researchers are looking up to is to consider the teaching of Mathematics in a cultural context. Ethnomathematical moves in teaching mathematical concepts have been considered in the recent times to be one of the most efficient way of teaching mathematics. Various theoretical discussions have been made towards this philosophy (Peni, 2019). The practical aspect of this mathematics philosophy has not been considered so much. In order to utilize the cultural know-how of the people and making mathematical concept and socially connected as the norms of culture demands, there is the need to consider Realistic Mathematics Education (RME) through ethnomathematics pedagogies (Azmi et al., 2018; Purwanti & Waluya, 2019; Sumirattana et al., 2017). There is the need to experiment through demonstrational lesson to investigate the impact of ethnomathematical moves on the teaching and learning of mathematics.

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 by (Rowlands & Carson, 2002) as Eurocentrism and deviated from curriculum best known through culture. This conforms to the view of mathematics as primarily white, with

European imagination and male genetically dominated. Practically in Ghanaian educational system, about 90% of students studying mathematics find it difficult to understand geometry because of the way it thought in schools. The mathematical constructs, concepts and ideas are western dominated in culture. Has the imitation of foreign cultural principles guiding the teaching and learning of mathematical content been helpful? Can mathematics educators then bridge the gap between Euro-Western idealisation of mathematical education to Afro-multicultural mathematics where we can exemplify mathematics concepts with indigenous issues from cultural perceptive? The argument surrounding this is of interest to some African Mathematics Educators who hold facts to ethnomathematics (Amit & Qouder, 2017; Davis & Seah, 2016; Mills & Mereku, 2016).

The learner is placed in the centre of learning situation to interact with several mathematical concepts integrated from formal perceptive. Mensuration and Geometry seems to be one of the broadest topics in many elementary and secondary schools. Most students dislike it and would not make any attempt to related problems that come in their external examinations. Teaching mathematics from cultural context could help bridge this gap. To what extent is there interconnection between what they know from their cultural perspective to what they intent learning from formal interactions in the said topic? Ethnomathematics encourages relationships and open dialogue in learning mathematics for classroom (Borba, 1990). The teacher can teach through ethnomathematics principles which students respond to it from their experience with their cultural understanding. According to Borba (1990), such interaction would help strengthens their socio-cultural roots since their foundational or root knowledge is now considered valuable in class. Whatever they learn would be understood well and be meaningful.

Every individual is surrounded by cultural imprints one way or the other. The Akan communities have various artifacts and among cultural imprints that can support the teaching of geometry. 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. Culture will continue to teach us meaningful mathematics if we open up to admit its precepts to the curriculum implementation. The pedagogical process mathematics educators adopt to teach selected topics such as geometry can enhance students' knowledge cognition. The connection between cultural diversity and subject-based concept teaching has been explored by (Orey & Rosa, 2004; Rosa & Orey, 2016). 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 "consideration on mathematics as human and cultural knowledge" (Bishop, 1994). There appears to be a change in the meaning of ethnomathematics as diversity within mathematics and within mathematical practices (Rosa & Orey, 2016). Thus, ethnomathematics is seen to describe the different mathematical practices that have its base concerning cultural diversity.

Several surveys have been done on ethnomathematics defined to be culturally influencing the mathematical approach to induce meaningful learning of mathematics. Kurumeh (2004) discusses the way in which students' immediate environment support ethnomathematical teaching and learning of mathematics in schools. Learning in Akan communities are surrounded by many ethnomathematics process and ethno-technology that can lead to clearer understanding of geometrical lessons. Home sweet home they say; (Kurumeh, 2004) see students who attend school from their own community as getting meaningful understanding of whatever they learn. It is a good practice in Ghana to see dominantly many Ghanaian (e.g., Akan communities) children attending community school existing in their immediate environment. Enukoha (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 favors the African child from the European child. There is the need to groom mathematics education for the African child instruction based on cultural materialistic and illustrations, examples, improvisations, surveys, case study etc. The frontiers of curriculum implementers could start experimenting the ethnomathematics based philosophy to see the way forward of the mathematics education.

Ethnomathematics methodology should be embraced in our school system as part of the curriculum implementation. Many mathematics educators (teachers) believe that there is no place for cultural constructs in mathematics teaching and learning. There should be 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 should intensify integrating ethnomathematical ideas into mathematics classrooms. In the light of finding the friendliest teaching approach for geometry lessons, this paper discusses ethnomathematics pedagogical moves and processes that could be used to teach elementary concept of geometry and the inherent of these mathematical concepts in the Akan culture.

### Objectives of the Study

The main objective was to:

1. Identify ethnomathematical Akan ethnomathematics processes that support the teaching and learning of geometry in Ghana
2. Demonstrate pedagogical actions of Akan ethnomathematics deemed to support the teaching and learning of geometry.
3. Investigate geometrical concepts knowledge-based in Akan artifacts through ethno-technology.

## METHOD

The research sought to demonstrate ethnomathematics pedagogical action on the teaching of geometry. The study is motivated by the theoretical framework on the teaching and learning of mathematical contents based on ethnomathematics handbook outlined by Forbes, (2018). Several ethnomathematics philosophers has sought and suggested the interest of making mathematics lesson and curriculum implementation ethnomathematics pedagogically based instruction (Peni & Baba, 2019; Putra, 2018; Rosa & Orey, 2019). The study sought the need to use an exploratory mixed method to investigate the impact of ethnomathematical moves in teaching and learning process. Ethnomathematics pedagogy were demonstrated on selected concepts in geometry that meets Akan ethnomathematics as resourceful teaching of the constructs. We explored the mathematical concepts in the Akan culture and demonstrate its effect on the teaching and learning of formal mathematics system.

Akan is a tribal community in Ghana, West Africa with diverse culture and sub-tribal communities scattered all over many geographical locations in Ghana. They possess a common ethnomathematics deem to support the teaching of many mathematical concepts such as geometry. The limitation exists for informal mathematical constructs where teaching and learning is scripted. Mathematics among the community members are passed on through oral tradition where the young learn by imitation from the older folks. Their children however take on to the formal education. There is the need to link what they know and interact with from their culture to the formal classroom where formal curriculum under Eurocentric idealization is met. There is the need therefore to investigate and demonstrate the need to mathematicize geometric content to make the teaching and learning friendliest.

## RESULTS AND DISCUSSION

Among Akan ethnomathematics is the collections of basic existing artefacts which clearly suggest their knowledge base of mathematical concepts from informal position. **Figure 1** shows some selected Akan artefacts used popular in most community Kitchen that undoubtedly picture mathematical sense, skills and knowledge based on critical implication to geometry, mensuration and general conics concept in mathematics. Akan indigenous artefacts come in different forms; earth bowl ware, mortar, buildings, clothing (batiks), and among others. There has been research done to investigate other linkage of ethnomathematics in relation to existing cultural (Pradhan, 2017; Pramudita & Rosnawati, 2019).


**Figure 1.** Traditional indigenous artifact showing various conics (Source: field survey)

Cultural artefacts create a means of conceptualizing ethnomathematics in connection to formal mathematics concepts (Garegae, 2015). Innumerable studies in mathematics education have concentrated on the design and implementation of didactical activities significantly based on architectural experience and on the manipulation of concrete objects and artefacts with the aim of fostering the development of particular mathematical meanings and thinking. For example, culture describe how, if not all, some mathematical concept thrives from informal knowledge based to the most formal that is widely accepted today. Students' use of specific artefacts in solving mathematical problems contributes to their development of mathematical meanings to the concept studied, in a potentially 'coherent' way with respect to the mathematical meanings aimed at in the formal teaching activity (Bussi & Xu-Hua, 2016). However, it is important to keep in mind that, in fostering the development of mathematical meanings an essential component is the students' sharing, comparing and evolving of strategies (which can be accomplished in a number of different ways). These mathematical meanings, of course, can include structure sense, evidence-based ethnomathematics such as artefacts that can serve as a resourceful teaching of the formal mathematical concept and general curriculum implementation. This can be promoted through a variety of different mathematical content picked from ethnomathematics perceptive to make transition to the formal classroom curriculum implementation (Bussi & Xu-Hua, 2016).

### Akan Ethnomathematics on Circular Artefact

From **Figure 1**, traditional indigenous artifacts from the selected part of Akan communities are typical ethnomathematics which speaks implication of both informal and formal mathematical concepts regarding conics-circles, cylinders, and cones etc. Below are some selected kitchen artifacts suggesting ethnomathematics of mensuration as the content scope of the SHS core mathematics.

Various traditional Ghanaian kitchen has circular artefact of which most children are exposed to before going to school (see **Figure 1**). 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.

### *Exploring the concept of pi $(\pi)$ from Akan ethnomathematics*

Most Akan techno-ethnomathematics base is connected to their artefacts and production of things. The figure below, for example is manufactured based on the manufacturer knowledge of circles (mensuration). The researcher was interested in finding out the manufacturers' knowledge in circle characteristics. When the radius, height and circumference was measured from **Figure 2**, the estimated *pi*, circumference and diameter were observed, as follows:


**Figure 2.** Asanka (earthbowl-ware) concept of *pi*

$$diameter\ (d) = r + r = 2r$$
$$pi\ (\pi) = \frac{circumference}{diameter} = \frac{C}{d}$$

Making circumference a subject of equations becomes

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

Note that the radius of the circular *asanka* displayed in **Figure 2** was 15.6 with a height (h) of 12.5 cm to find the *pi*, we take the ratio of C : d, as follows:

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

Hence, the estimated *pi* of $\pi = 3.14$ depicts precision in the craftiness of the circular artefact to conform to the formal concept of $pi\ (\pi)$.

The mathematical concept of mensuration is seen as some of the artefacts are engineered as circular based. For example, circles, cones, cylinders, parabolas, ellipse, and hyperbolas are seen from the various kitchen technological tools used for grinding, storing food and water, eating earthen bowls and among others. For example, investigating into the concept of *pi* in selected Akan circular objects (as seen in **Table 1**) reveals a close margin estimate of $\pi = 3.142$.

Students in their groups sampled several artifacts from their traditional homes and were asked to measure the circumference $(C)$ and diameter $(d)$ of each objects measured in centimeters $(cm)$. Students placed a thin rope around each circular artifact and stretched their measurement on rule to record the results. Similarly, they placed circular objects between two hard flat surfaces parallel enough to show the diameter for measurement. The results of their findings $(C/d)$ are tabulated in **Table 1**.

We investigate further to find out whether some selected Akan indigenous circular artefacts are well crafted with formal concepts of circle. What characterizes the regularity of circle is the concept of *pi(π)* which is approximately considered as 3.142 (3 d.p.). A marginal error of approximating *pi* to 3.1 (1 d.p) suggest selected Akan ethnomathematics artefact from focus group who make and sell them has on the average, the concept of *pi* approximately 3.14. The knowledge based in creating, crafting, and engineering them shows a significant informal mathematics. Children dairy use of them in their homes put to some extent, 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 (D'Ambrosio, 1985; Favilli, 2007; Rosa & Orey, 2016; Shirley, 2001).

**Table 1.** Selected Akan circular artefact with concept of *pi* ($\pi$)

| Circular artefact | Akan name | Circumference (C) cm | Diameter (d) | ($C/d$) 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 |

Source: Field survey from Akan traditional homes (2020)

We can establish geometrical linkage to formal mathematical concepts from this Akan ethnomathematics on artefacts. **Table 2** 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 responses were jotted down with their reasons.

Participants were able to link their formal mathematics knowledge on geometry to what they see from their neighbourhood. Participants were able to link their formal mathematics knowledge on geometry to the problem given in **Table 2** 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 teaching (Baccaglini-Frank, 2015) turns 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 dairy exposal to such artefacts would help them solve mathematics problem associated with merging the formal and informal. Students were given the following problem from **Figure 3**.

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

**Table 2.** Respondents' view on their knowledge of geometrical shapes to identified artefacts from their community

| Question item | Answer/response | Reason for response |
|---|---|---|
|  | 1. Cone<br>2. Cylinders<br>3. Rectangle<br>4. Circles | The figures have circles with conical walls and rectangular or trapezium entrances in an irregular form. |
|   | 1. Rectangle<br>2. Triangle<br>3. Square | Building walls are rectangular in shape. Roofing edges are triangular in shapes. |
|  | 1. Circles<br>2. Cones<br>3. Cylinder<br>4. Ovals | Earthbolws are circular in nature. Tapoli (blender) are truncated cones. Yaawa (jars) are spherical. |

Source: Field survey from Akan traditional homes (2020)

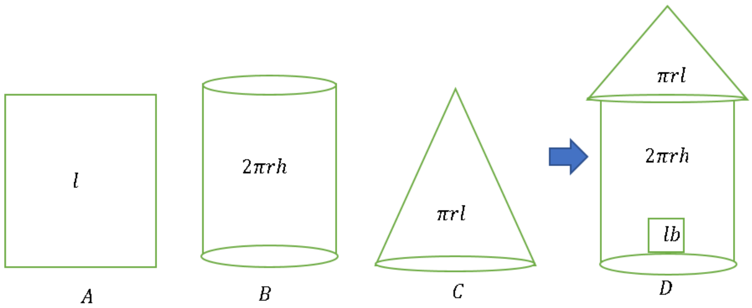
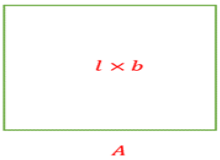
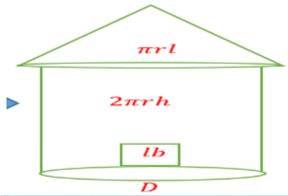
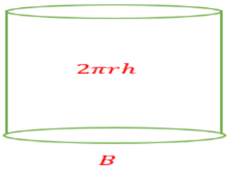
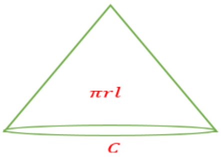
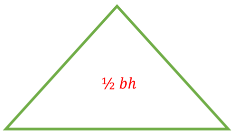
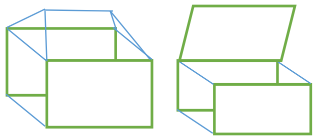
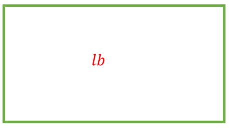
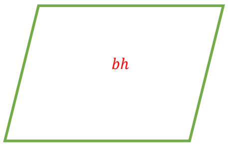



**Figure 3.** Problem spacemen from a merge of Akan informal ethnomathematics to the formal

Few of the students were able to figure out some routing 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 we can infer that they have internalised the structure of the grid. The use of structure sense is embedded within this example as seen from **Figure 3**. 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', etc. 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 (see **Figure 3** and **Table 3**).

Akan ethnomathematics is based on ethno-technology; a situation where indigenous technology is seen from traditional engineering processes. Technology and science is ruling the world in recent times. The bases of technological revolutions evolved from societal needs with background rooted from what culture suggests. The Akan ethnomathematics systems has certain indigenous technological applications. The technology is governed by how they use their knowledge of mathematics in building, solving their societal pertinent problems, making tables and chairs, chop-box and among others. **Table 3** shows how some Akan ethno-technology has the base knowledge of geometry and mensuration.

**Table 3.** Exemplification of geometric and mensuration problems with ethno-technology application

| Plane ($P_n$) | Plane figure/shape | Geometrical identification | Ethno-technology |
|---|---|---|---|
| P1 |  | Square |  |
| P2 |  | Cylinder |  |
| P3 |  | Cone | |
| P4 |  | Triangle |  |
| P5 |  | Rectangle |  |
| P6 |  | Parrellogram | |

Source: Field survey (2020)

Akan concept of geometrical ethnomathematics is applied in their various artefacts and technological know-how as depicted from **Table 3**. Geometrical knowledge is used to create habitable houses mostly found in the Akan rural communities which mostly hold the typical Akan cultural systems.

The implication of these informal ethnomathematical concepts to formal teaching is enormous. To bridge the gap between cultural-based mathematics and formal mathematics, there is the need to mathematicised cultural-based mathematics as suggested by Peni, (2019). According to Oray & Rosa (2016), mathematization is the development of a given problem, that is, the transformation of the problem into mathematical language. A typical example is to teach mensuration in secondary school where traditional artefacts with cylindrical and circular based would be used to exemplified solutions (see **Figure 3**). The need to consider ethnomathematics pedagogical approach to mathematics teaching has been recommended. A manual to assist such application of ethnomath to formal teaching process has been crafted for mathematics educators to consider (Baba & Iwasaki, 2001; Forbes, 2018; Peni, 2019; Putra, 2018).

Knowledge of circular artefacts discussed so far suggest to the most formal way the concept of conics can become meaningful. There are embedded concepts of circles, parabola, ellipse, and hyperbola in the various illustrations of Akan ethnomathematics (see **Figure 4**). 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.

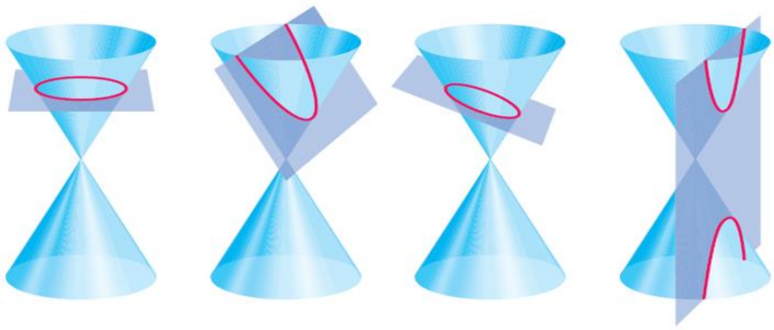



**Figure 4.** Some selected conic section closely connected to Ghanaian ethnomathematical constructs suggested by the school-based mathematics curriculum (Sullivan, 2010)

From **Figure 4**, an assembly of conic section comprising of circles, parabola, ellipse, hyperbola, and other geometrical course description is suggesting a close connection to Ghanaian Akan 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.

### Culture and Geometry

In the teaching of total surface area for specimen A, B, and C from **Table 2**, a multifaceted of these 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. All things been equal, students who are believed to come from communities where these are found or perhaps who live in such apartments might be able to internalize the solution better than a student from non-Akan communities where these are not found. This might be as a result of familiarity of this to conform to traditional indigenous building technology found in an around the learners' environment. The students there would find the problem quite close to their environmental exploration, and the stimulus idealization might be sharper than students with equal ability from where these are not found. This conform to Vygotsky theory where the students' internalization falls within his or her proximal zones (Vygosky, 1998). Students understanding the mathematical concept is fostered by idealization from the environment, culture and tradition best known to the students (Clark et al., 2013).

With regard to this connectedness, Sunzuma and Maharaj (2019) studied mathematics teachers' perception and challenges of implementing ethnomathematics in the Zimbabwean classroom as suggested by the mathematics syllabus. The school system has indicated that geometry should be connected to the learners' environment and culture. There is existence of teacher- related challenges to the incorporation of ethnomathematics approaches into the teaching of geometry. Teachers who expressed their views on the challenges that affect the integration of ethnomathematics approaches into the teaching of geometry emphasized on resistance for change. Major challenges (Sunzuma & Maharaj, 2019) found included lack of knowledge on ethnomathematics approaches and how to integrate these approaches into the teaching of geometry; teachers' lack of geometry content knowledge, teachers' views of geometry taught in schools, teachers' competence in teaching geometry, teaching and professional experience as well as resistance to change by teachers. There is recommendation of redesigning the curricula to include ethnomathematics approaches to teaching as well as the need for in-service training on ethnomathematics approaches to all teachers.

There are quite a number of cultural dynamics from not only Akan ethno-technological perspectives but also general multicultural settings that really support curriculum implementation in the formal 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. There is a clearer interconnection between an informal ethnomathematics ideas to the formal mathematics presumed by most researchers as Eurocentric (Powell & Frankenstein, 1997). The implementation of the Ghanaian mathematics core curriculum has a close imprint of ethnomathematical ideas, but the implementation of these through teaching and learning do not consider ethnomathematics. The broad structure and scope of the mathematics curriculum have a close connection to many traditional and socio-cultural dynamics. These cultural dynamics support the content-based structure of the subject discussed so far.

### Measurement of Length and Distance

Akans have their own measurement system in their communities. They still use their traditional measurement system. New generation use modern system of measurement tools to measure length and distance. Among the Akan people traditional measurement system include arm-stretching, leg footing, and among others. The distance and length units are *basafa* (arm's length), *kwansin* (miles), and *anamon* (kilometers). If they have to measure the very short length of anything they use stretched fingers (*nsayƐm*) measured formerly (in SI unit) as inches. Similarly, they use *insatea* (finger) to measure distance between tips of the thumb to tip of the pointing figure as presented in following **Figure 5**.

**Figure 5.** Foot and hand counting system of measurement (Source: field survey)

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. These fundamental body movements of ethnomathematics is 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, 2019).

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. This approach is good in introducing measurement of length through arbitral exploration. 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 feet 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 able to established meaning to perimeter of rectangles, squares and recognition of Pythagorean theory, as follows:

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

As seen from **Figure 6**, the area and perimeter of the triangular and rectangular plots were found using the foot-step and hand arbitral counting system of Akan ethnomathematics.

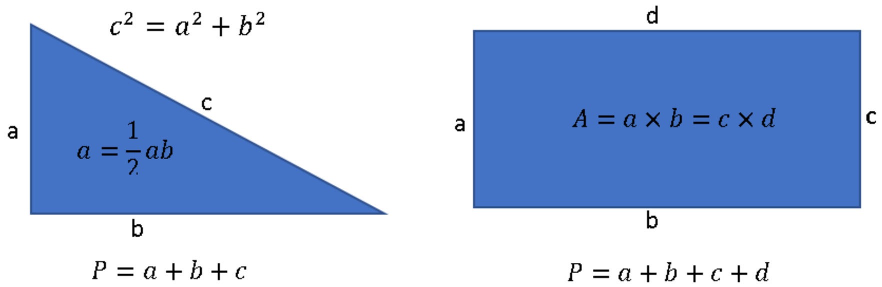



**Figure 6.** Field parameter and area measurement using foot and hand counting (Source: field survey)

The key content and mathematical concept or construct the ethnomathematics illustrates (see **Figure 6**) was to recognize the Pythagoras theorem based on Pythagorean principles to establish the area of the fields as well as the parameter enclosed to the given plot. The mathematical processes associated with these ethnomathematics suggests a metacognition of Akan concept of geometry illustrated through body movements and gestures, games, artefacts and indigenous technology such as buildings, roofing, and among others.

The Akan kente cloth depicts the geometrical knowledge in ethnomathematical concepts that best describes or link the formal mathematical concepts of geometry and mensuration. **Figure 7** shows kente designs in various form of geometrical shapes such as rectangles, rhombus, triangles, kites, squares arrows stripes, and among others. **Figure 7** also shows other designs that were made out of rhombus, kite, and circular designs, respectively. The technological know-how of cloth making shows Akan knowledge of geometry similar to other studies' findings carried out by Africa researchers of ethnomathematics. It can be applied as resourceful teaching in elementary geometry concepts. Most of African traditional artefacts with ethnomathematics are dominantly geometrics based; reflecting on their dominant knowledge in Euclidean geometry, circles and general conics concepts in mathematics.

**Figure 7.** Examples of Akan kente clothes (source: field survey of Akan kente clothes)

## CONCLUSIONS AND RECOMMENDATION

Culture spells out a lot of mathematical contents. Akan ethnomathematics have evidences of geometric and mensuration content. This ethnomathematics processes take the form of artefacts such as earth-bowl-ware, blinder, jars, kente clothes, bowls, and among others. The Akan ethnomathematics support the teaching and learning of mathematical concepts of which mensuration and geometry are not exception. Evidence from discussions and analyses of Akan ethnomathematical processes shows a clearer interconnections of the formal and informal mathematical contents enshrined in school-based curriculum. The pedagogical moves adopted from this basic ethnomathematics are applicable in various resourceful teaching processes. The existence of ethnomathematics among the Akans culture helps the children from the communities to follow the lesson development to enhance their mathematical skills acquisition. The Akan ethnomathematics revealed the concept application of conics *pi* ($\pi$) enhancing how students can conceive this mathematical concept in mensuration topic from the formal teaching perspective.

Typically, among the Akans ethnomathematics is application of informal mathematical applications called ethno-technology. This has been the basis of Akan indigenous traditional creation of artefacts that come in the form of kente weaving process to bring geometrical shapes. Buildings and traditional artefacts were engineered from the ethnomath and ethno-tech idealization. The informal position of knowledge transmission of these ethnomathematical ideas is a great limitation to extracting a connection to the formal Eurocentric approach of teaching mathematics. To start from somewhere, there is the need to consider mathematization of informal ethnomathematics to adjust somehow to the formal curriculum implementation processes through appropriate ethnomathematical pedagogies. Culture has a lot to give mathematics educators if we conform to admit its integration into the teaching and learning processes.

We recommend further research into the practical effect of ethnomathematics move in teaching other mathematical concepts in several communities where there exists cultural diversity. It is suggested that, mathematics educators adopt ethnomathematics methodology by integrating it into the curriculum implementation process to check its impact on the teaching and learning of mathematics.

**Author contributions:** All authors have sufficiently contributed to the study, and agreed with the results and conclusions.

**Funding:** No funding source is reported for this study.

**Acknowledgements:** The authors would like to thank all focus groups in the Akan community (a major tribe of Ghana, West Africa) for their openness to give information surrounding Akan ethnomathematics as well as Students and teachers from Techiman Municipal for their contributions to this research, as well as their significant time and effort.

**Ethical statement:** Authors stated that the study did not require institutional ethics committee approval from our Colleges of Education (SDA College of Education, Asokore-Koforidua and University of Education Winneba), Ghana to conduct the study since data were gathered from the voluntary participation of the respondents. Informed consents were obtained from the study participants. Any personal information was kept confidential. Authors further stated that the participants were given consent forms to sign to show their willingness to participate. Any data that might be used to identify a person was anonymously considered. Majority of the artifacts displayed were field survey. Any other documented relevant sources have also been duly acknowledged.

**Declaration of interest:** No conflict of interest is declared by authors.

**Data sharing statement:** Data supporting the findings and conclusions are available upon request from the corresponding author.

## REFERENCES

Acharya, B. R. (2019). Indigenous geometrical knowledge of Tamang community from their cultural practices. *International Journal on Future Revolution in Computer Science & Communication Engineering*, *3*(9), 38-42.

Amit, M., & Qouder, F. A. (2017). Weaving culture and mathematics in the classroom: The case of Bedouin ethnomathematics. In M. Rosa, L. Shirley, M. E. Gavarrete, & W. V. Alangui (Eds.), *Ethnomathematics and its diverse approaches for mathematics education* (pp. 23-50). Springer. https://doi.org/10.1007/978-3-319-59220-6

Azmi, A. L., Wardono, W., Cahyono, A. D. (2018). Mathematics literacy on creative problem solving with realistic mathematics education approach assisted by e-learning schoology. *Unnes Journal of Mathematics Education*, *7*(3), 188-194. https://doi.org/10.1088/1742-6596/1321/3/032094

Baba, T., & Iwasaki, H. (2001). The development of mathematics education based on ethnomathematics (2): Analysis of universal activities in terms of verbs. *International Journal of Curriculum Development and Practice, 3*(1), 65-75.

Bishop, A. (1994). *Ethnomathematics – Challenging eu rocentrism in mathematics education* [Book review, ZDM]. https://www.emis.de/journals/ZDM/zdm985r4.pdf

Borba, M. C. (1990). Ethnomathematics and education, *For the learning of mathematics, 10*(1), 39-43.

Bussi, M. G. B., & Sun, X. H. (2016). *Building the foundation: Whole numbers in the primary grades* (23rd ed.). Springer.

Cycleback, R. D. (2014). *A brief introduction to ancient counting systems for non-mathematicians*. Hamerweit Books.

D'Ambrosio, U. (1985). Ethnomathematics and its place in the history and pedagogy of mathematics. *For The Learning of Mathematics, 5*(1), 44-48.

D'Ambrosio, U., & Rosa, M. (2017). Ethnomathematics and its pedagogical action in mathematics education. In M. Rosa, L. Shirley, M. E. Gavarrete, & W. V. Alangui (Eds.), *Ethnomathematics and its diverse approaches for mathematics education* (285-50305). Springer. https://doi.org/10.1007/978-3-319-59220-6_12

Davids, A. B. (2019). "Math dadness": A project to combine high school mathematics, literacy, and sports. *The Official Journal of the South Carolina Council of Teachers of Mathematics, 4*(1), 17-20.

Davis, E. K., & Seah, W. T. (2016). Socio-cultural factors: A missing variable in mathematics pedagogy in Ghana. *Ghana Journal of Education: Issues and Practices, 2*, 40-58.

Enukoha, O. I. (2002). *Ethnomathematics and Achebe's things fall apart* [Paper presentation]. The West African Conference on Languages and interaction Unical Calabar.

Favilli, F. (2007). *Ethnomathematics and mathematics education*.

Forbes, W. A. (2018). *Using ethnomathematics principles in the cassroom: A handbook for mathematics educators*. Education MRP.

Garegae, K. G. (2015). The case of cultural artifacts: Conceptualizing ethnomathematics as a bridge between peace and conflict in the world of intolerance. In M. A. George, S. S. Scatolini, & S. A. David (Eds.), *Including the other: Acknowledging difference in education, language and history* (pp. 128-137).

Kurumeh, M. S. C. (2004). *Effect of ethnomathematics approach on students' achievement and interest in geometry and mensuration* [PhD thesis, University of Nigeria].

Kusuma, D. A., Suryadi, D., & Dahlan, J. A. (2019). Improving external mathematical connections and students' activity using ethnomathematics. *Journal of Physics: Conference Series*, *1157*(3), 032120. https://doi.org/10.1088/1742-6596/1157/3/032120

Machaba, F. M. (2018). Pedagogical demands in mathematics and mathematical literacy: A case of mathematics and mathematical literacy teachers and facilitators. *Eurasia Journal of Mathematics, Science and Technology Education, 14*(1), 95-108. https://doi.org/10.12973/ejmste/78243

Mills, E. D., & Mereku, D. K. (2016). Students' performance on the Ghanaian junior high school mathematics national minimum standards in the Efutu Municipality. *African Journal of Educational Studies in Mathematics and Sciences, 12*, 25-34.

Naresh, N. (2015). The role of a critical ethnomathematics curriculum in transforming and empowering learners. *Revista Latinoamericana de Etnomatemática [Latin American Journal of Ethnomathematics], 8*(2), 450-471.

Orey, D. C., & Rosa, M. (2004). Ethnomathematics and the teaching and learning mathematics from a multicultural perspective. *The Journal of Mathematics and Culture, 1*(1), 57-78.

Peni, N. R. N. (2019). Development framework of ethnomathematics curriculum through realistic mathematics education approach. *IOSR Journal of Research & Method in Education*, *9*(4), 16-24.

Peni, N. R. N., & Baba, T. (2019). Consideration of curriculum approaches of employing ethnomathematics in mathematics classroom. *Journal of Physics: Conference Series, 1321*(3), 032125. https://doi.org/10.1088/1742-6596/1321/3/032125

Powell, A. B., & Frankenstein, M. (1997). *Ethnomathematics: Challenging eurocentrism in mathematics education*.

Pradhan, B. J. (2017). Mathematical ideas in Chundara culture: Unfolding a Nepalese teaching and learning system. In M. Rosa, L. Shirley, M. E. Gavarrete, & W. V. Alangui (Eds.), *Ethnomathematics and its diverse approaches for mathematics education* (pp. 125-153). Springer. https://doi.org/10.1007/978-3-319-59220-6_6

Pramudita, K., & Rosnawati, R. (2019). Exploration of Javanese culture ethnomathematics based on geometry perspective. *Journal of Physics: Conference Series*, *12*(1), 012002. https://doi.org/10.1088/1742-6596/1200/1/012002

Purwanti, K. L., & Waluya, B. (2019). Mathematical literacy ability with RME (realistic mathematics education) approach in fifth grade students. *Journal of Physics: Conference Series, 1321*(2), 022118. https://doi.org/10.1088/1742-6596/1321/2/022118

Putra, M. (2018). How ethnomathematics can bridge informal and formal mathematics in mathematics learning process at school: A framework. *For the Learning of Mathematics*, *38*, 11-14.

Rosa, M., & Orey, D. C. (2016). State of the art in ethnomathematics. In *Current and future perspectives of ethnomathematics as a program* (pp. 11-37). Springer. https://doi.org/10.1007/978-3-319-30120-4

Rosa, M., & Orey, D. C. (2019). Ethnomathematics and the responsible subversion of its pedagogical action: An investigation based on three anthropological approaches. *Revista Brasileira de Estudos Pedagógicos [Brazilian Journal of Pedagogical Studies]*, *100*(254), 191-209. https://doi.org/10.24109/2176-6681.rbep.100i254.3939

Rowlands, S., & Carson, R. (2002). Where would formal, academic mathematics stand in a curriculum informed by ethnomathematics? A critical review of ethnomathematics. *Educational Studies in Mathematics, 50,* 79-102. https://doi.org/10.1023/A:1020532926983

Scott, L. B. A. (2018). *African American high school students' attitudes toward mathematics and perceptions of extant culturally relevant pedagogy and ethnomathematics* [PhD thesis, California State University - San Bernardino].

Shirley, L. (2001). Ethnomathematics as a fundamental of instructional methodology. *ZDM*, *33*(3), 85-87. https://doi.org/10.1007/BF02655699

Sumirattana, S., Makanong, A., & Thipkong, S. (2017). Using realistic mathematics education and the DAPIC problem-solving process to enhance secondary school students' mathematical literacy. *Kasetsart Journal of Social Sciences, 38*(3), 307-315. https://doi.org/10.1016/j.kjss.2016.06.001

Sunzuma, G., & Maharaj, A. (2019a). Teacher-related challenges affecting the integration of ethnomathematics approaches into the teaching of geometry. *Eurasia Journal of Mathematics, Science and Technology Education*, *15*(9), 2-15. https://doi.org/10.29333/ejmste/108457

Unodiaku, S. S. (2018). *Teaching geometrical and mensuration proofs with origami-based instrumental model approach among seniorsecondary school students in Enuga state*. https://man-nigeria.org.ng/abstract?sid=ABA-EDU-2018-1-3

Vygosky, L. (1998). *The problem of age*. https://www.marxists.org/archive/vygotsky/works/1934/problem-age.htm