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The Ethnomathematics of Indigenous Burnt Bricks Production in the Benue Valley

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Abstract
Mathematics education that is culture-oriented emphasizes originality of thought and encourages the virtue of creativity. The approaches of ethnomathematics are embedded in the everyday practice of students and can stimulate classroom participation, develop mathematical intuition, enhance number sense and introduce mathematical concepts in an engaging way. This exploratory study focuses on the mathematics lessons derivable from the local process of producing burnt bricks within the Benue Valley. The study draws connections from the steps involved in burnt bricks making to the concepts taught in the Basic Mathematics Curriculum. The study summits that the onus is on the mathematics teacher to innovatively incorporate elements form their learners' environment into instructional sequence in order to demystify the perceived abstractness of mathematics.

Keywords: Ethnomathematics, Mathematics Education, Burnt Bricks Production, Benue Valley, Basic Mathematics

Introduction

Africa has always pride herself as a cradle of rich indigenous knowledge systems. This richness is seen in the daily practices of ordinary people; in their culture, agriculture, architecture and religion. The signature of advanced scientific thinking can be found across several distinct cultural artefacts and socio-economic structures of ordinary people. Ranging from the knitted grass huts of the nomadic Fulanis to the mud houses of the Benue Valley civilization, there can be seen distinct manifestation of mathematical knowledge in the form of geometric patterns, solid shapes and meaningful use of numbers.

Among the numerous indigenous mathematical feats of the people of the Benue Valley, the one which stood out the most is the measured process of making burnt bricks, the ubiquitous building blocks for diverse local constructions works in the region. The Benue River is the longest tributary of the Niger (about 650 mile). It rises in the Adamawa Plateau of Northern Cameroon, from where it flows west, and through the town of Garoua and Ladgo Reservoir, into Nigeria south of the Mandara mountains and through Makurdi before meeting the Niger River at Lokoja. The floodplain soils occupy about 1,179,400 hectares along the river Benue and are useful for agricultural production and construction works.

Historically, the civilization of Benue Valley have always been a melting pot of different cultures. The region has been the home of to a changing constellation of peoples over many centuries. Presently, the Benue Valley is where the Jukuns, Tiv, Idoma, Igala, Ebira and Afo people live, among others. The incursions of the Fulani Jihadists in the early era of the region caused dynamic dislodgement of peoples who later gradually regrouped into communities and exchanged ideas and forms with their new neighbours. These destabilizing events help explain the fluid identities of traditional practices that span the lower Benue and its open frontier with the Middle Benue.

The richness of the soil of the Lower Benue Basin makes agricultural production the dominant occupation of the people of the region. The huge deposit of clay along the Benue valley also made the region a socio-economic belt in the production of all kinds of bricks for building and other civil engineering works. Although, modern methods of making bricks abound in the region, the time-proven methods of burning clay bricks by the locals has remain a cultural trade passed down from one generation to the other.

Focus on the indigenous method of burnt bricks production is timely, considering the strands of mathematics employed in the entire process. The ordinary people who engage in burnt bricks production do so for the purpose of generating major and minor incomes for their families. Majority of these bricks makers lack Basic Education and may be entirely "illiterate" in the modern sense of literacy. But they have honed the skills of their crafts as passed down to them and in the process have preserved amazing inherent mathematical ideas deployed in the practice of their trade even before the arrival of the missionaries and colonial masters. The implication of this fact is that there is mathematics to be learned and used from the practices of the ordinary people from which the conventional pupil emerged into the modern classroom.

If mathematics is present in the daily activities of the child, then the teaching and learning of the school subject should make a better sense when connected to what the child already knows. In other words, the foundation for a good mathematics education for the child is his own fund of indigenous mathematical knowledge, acquired over time form the cultural practices of his people. Building firmly on this foundation should make mathematics as ordinary as what the child can deduce from his neighbourhood, culture, history and contemporary society.

The objective of the present article is to explore the mathematics lessons derivable from the process of producing burnt bricks within the Benue valley. What connections can be made from the craft of bricks making to the concepts taught in the Basic Education Mathematics Curriculum? This probe, along with the need to draw attention to the countless appearances of mathematics in students' local practices forms the focus of other current exposition.

Indigenous Mathematical Knowledge

Claudia Zaslavsky is one of the early scholars of African indigenous mathematical knowledge systems. In discussing her motivation for her phenomenal works, Zaslavsky (1994) recounted that books and articles on the history of mathematics were of little value to her research. If they mentioned Africa at all, it was generally to recount the quaint practices of the people who were least advanced mathematically. But she mentioned two exceptions among pre-World War II publications. One of the works made reference to a 1915 article by the Austrian anthropologist Marianne Schmidl in which she warned: "one must be extremely cautious about accepting the accounts of the inability of 'primitive' people to count in higher denominations" (Zaslavsky, 1994, p.4). Zaslavsky noted that this was the only instance in works from the period where the author placed quotations marks around the word "primitive".

The other exception for Zaslavsky is an obscure book by Dr. O. F. Raum. Raum (1938) described the mathematical practices and games of various African peoples, and expressed a strong belief in their mathematical abilities. He stated that good teaching "lays down the importance of understanding the cultural background of the pupil and relating the teaching in school to it" (Raum, 1938, p.5). Zaslavsky (1994) noted that if the colonial authorities has possessed a genuine interest in educating African students in those early days, they certainly would not have banned the Universal African game in its many versions, called *Oware*, *Ayo*, *Omweso*, *Bao* and dozens of other names. Known also by the generic name "Mancala" (Abah, 2017), it is considered by some game experts to be one of the best mathematical games in the world, with European observations often commenting on the speed and finesse exhibited by the players (Zaslavsky, 1994).

In present times, research in Ethnomathematics has unravelled the wealth of Mathematical ideas and concepts that are indigenous to African peoples and culture. These research have identified the crux of the crises of African cultures to be the issue of African cultural identity. A people's cultural identity (including their awareness of such an identity) is seen as the springboard of their development effort. Africa needs a culture-oriented education that would ensure the survival of African cultures if it emphasized originality of thought and encouraged the virtue of creativity. Scientific appreciation of African cultural elements and experience is considered to be one sure way of getting Africans to see science as a means of understanding their cultures and as a tool to serve and advance their cultures (Gerdes, 1996).

Every society develops its own particular mathematics. So many factors are involved – heritage, environment, religious beliefs, technological advances, artistic inclinations, how people make their living – all have an effect on the development of their mathematics (Zaslavsky, 1994). Some of these developments have found their way into the school curriculum. For instance, pupils speak of "Hindu-Arabic" (more properly "Indo-Arabic") numerals and "Roman" numerals, yet most students have no idea as to their origin. To them mathematics springs full-blown out of a textbook or a teacher's head. Students are not given the opportunity to recognize the role of human beings of various cultures in the creation of mathematical ideas (Zaslavsky, 1994).

Gerdes (1996) observes that African countries face the problem of low levels of attainment in mathematics education. Mathematics anxiety is widespread. Many children (and teachers too!) experience mathematics as a rather strange and useless subject, imported from outside African, as something that exists only in schools. But does this image of mathematics corresponds to reality?

Mathematics exists as a body of truth about relationships between abstract entities and structures. These abstract relationships are reflected or instantiated in various forms and at different levels in the concrete structure of the physical world. Even in its most complex form, mathematics as a school subject is rooted in reality with applications in everybody life (Abah, 2016). This perspective to mathematics is what has been termed "Ethnomathematics".

The application of ethnomathematical approaches allows the opportunity to examine local knowledge systems and give insights into forms of mathematics use in diverse contexts and cultural groups. The pedagogical approach that connects this diversity of mathematics is best represented by a process of translation and elaboration of the problems and questions taken from daily phenomena. The ideas generated from real life attachments to mathematical concepts can truly create conflict situations in which students are encouraged to reflect upon the rules that define their action dealing with the concept (Bernardes & Rogue, 2015 in Abah, 2016). This approach results in both sensitive and historical thinking, medicated by bodies, signs, artefacts, and cultural meanings giving rise to a non-mentalist conception of thought (Abah, 2016).

As well as describing mathematical symbolism, applications and practices which are culturally distinct, ethnomathematics will be assumed to include mathematics concepts, systems, modes of thinking, and meta-mathematics, such as what counts as a proof, beliefs about how mathematics relates to the world, and values implicit in mathematics (Barton, 1992). In answering why it is important to introduce ethnomathematical perspectives into the mathematics curriculum, Zaslavsky (1994) suggests that student should recognize that mathematical practices arose out of the real needs and interests of human beings. They should know that a great deal of the mathematics that they learn in elementary and secondary school originated in Asia and Africa centuries before Europeans were aware of more than the most elementary aspects of mathematics. Students should learn how mathematics impacts on other subject areas – social studies, language arts, fine arts, and the sciences. Most importantly, they should have the opportunity to see the relevance of mathematics to their own lives and to their community. Students should see reasons to research their own ethnomathematics.

Mathematics education should recognize students' out-of-school mathematical experiences, their own ethnomathematics. One of the out-of-school activity students from the Benue Valley region are aware of is the craft of making hard burnt bricks. This ubiquitous approach to brick making is prevalent for students from this area, considering that most of the houses they live in are constructed with burnt bricks. Some of the students are also involved at one stage or the other in the production process, to raise money to support themselves and their families. What mathematical lessons are derivable from this method of producing bricks for building projects across and beyond the region?

The Making of Burnt Bricks

The use of bricks in building and construction in the Benue Valley pre-dates the colonial era. Form early times, dwellers along the Benue valley trough construct their round huts by moulding the walls with sticky clay mud. In this style of building, chunks of clay mud are packed upon each other and moulded upwards with hands without any noticeable joints or plastering. Still, weak fissures existing between the layers or chunks of clay mud becomes visible cracks as the wall ages. These cracks may result in total collapse of large portions of the moulded wall, particularly during the long rainy season.

A way of minimizing wall collapse due to mud fissures is to first mould units of mud blocks which are allowed to get dry and strong before being used in the building of walls. The strong blocks, dried in the sun are then placed upon each other and held together by mortar made of viscous clay mud. This second approach extended the life span of the wall of buildings. However, very damp conditions around the wall can still soften both block and joint materials, resulting in partial or total collapse of the building. This existential problem with normal mud blocks necessitated the burning of mud blocks to further strengthen building to withstand adverse wet conditions.

Clay bricks are man-made materials that are widely used in building, civil engineering work, and landscape design. One of the legacies of the colonial government in Africa was the scattered pieces of colonial and government flats built with clay bricks dotted within the countries especially along the coastal areas (Baiden, Agyekum, & Oferi-Kuragu, 2014). Although the practice of burnt clay brick manufacturing was modernized by the missionaries who continued to produce bricks and tiles even after the Second World War, it is the in-expensive indigenous clay bricks burning of the people that persisted into modern times. Certain properties of these burnt bricks makes them desirable for local building construction works.

Baiden *et al.* (2014) provides in-depth details on the properties of burnt bricks. Generally, a good brick must be hard, well burnt, uniform throughout, sound in texture and colour, sharp in shape and dimension, and should not easily break when stuck against another brick or dropped form a height of about one metre. Among the desirable properties of burnt clay bricks are compressive strength, density, thermal stability, porosity, sound insulation, fire resistance, durability, and water resistance (Baiden *et al.*, 2014).

The following steps are involved in Burnt Bricks Production:

Step 1: A wooden mould, with inner dimensions being 10 inches long, 5 inches wide and 5 inches high, has to be constructed from strong plane planks. It is firmly knotted or nailed with a two small handles attached to the side.

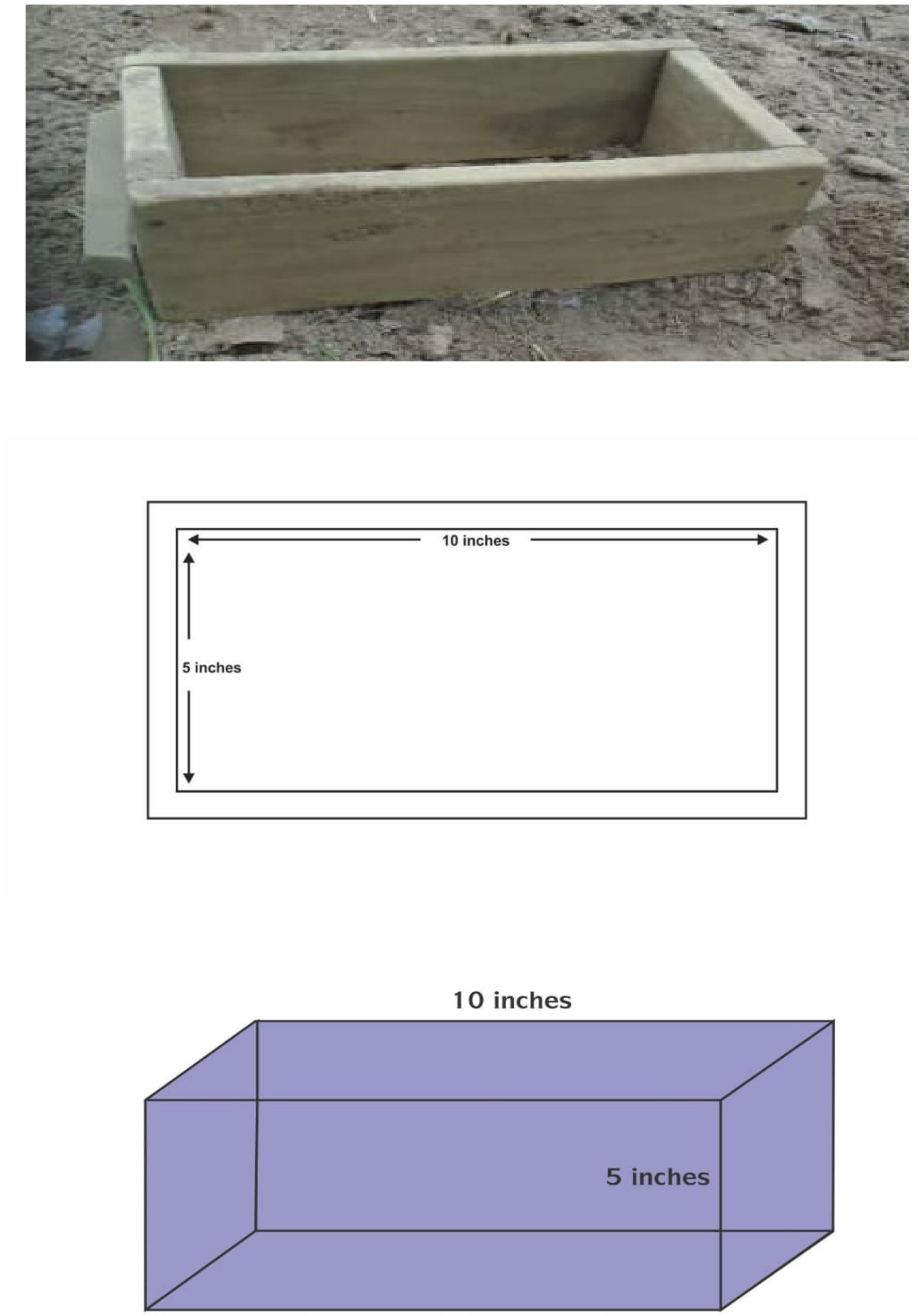

Figure 1: Wooden Mould

Step 2: Clear and level the ground where the bricks are to be laid.

Figure 2: Cleared Ground for laying Bricks

Step 3: Dig a heap of soil. The size of the heap depends on the number of blocks to be produced. For higher number of blocks, the heaps may have to be dug out in different places.

Step 4: Wet the heaped soil to soften it. The soil is then mixed by turning with a hoe and pressing it with the feet. This stirring is repeated until the mud is sticky and viscous. The lump of wet clay mud is then left for at least 12 hours. When this is done, the clay mud becomes ready for the laying of bricks.

Figure 3: Wet Heap Mixed to become Viscous

Step 5: Now the actual laying of bricks is carried out as follows, on the smooth ground prepared in step 2 above.

i. The rectangular wooden mould is dipped (not soaked) in water so that it will not stick to its intended content. This wetting is also required to obtain very smooth bricks.

ii. Fill up the wooden mould with the mud and press it firmly with the hand.

iii. Draw out the mould by lifting the handle. This is done slowly, carefully and gently to leave behind a firm block of mud.

Figure 4: Block Laying

Step 6: Repeat step 5 until the heap of wet clay mud is exhausted.

Step 7: Cover the laid bricks with grasses to prevent them from cracking. Allow the covering to stay for 3 to 5 days.

Step 8: Remove the covered grasses and allow the bricks to dry up in the sun.

Step 9: *Packing and arrangement for baking:* This process requires bringing the dry bricks together and arranging them systematically. The arrangement is done such that two tunnels measuring 3 feet wide and 4 feet high is formed across the width of the packed blocks. The tunnels are to be big enough for firewood to fit in.

Figure 5: Loading Tunnels with Firewood

Step 10: The tunnels are then loaded with logs of fresh firewood. This is done while the arrangement of bricks in still half-complete. It is not advisable to crawl into the tunnel with bricks packed up on it; this is to avoid accidents that may result from the collapse of the bricks. So, the logs of wood are loaded into the tunnel before the arrangement of bricks on top is completed.

Step 11: To prevent heat loss, cover the spaces around the arranged bricks with mud. In other words, the four sides and top of the arranged blocks are plastered with thick mud. The top of the bricks is also covered with grasses. This makes the entire set-up a kind of a kiln.

Step 12: Put fire to the loaded firewood in the two tunnel and allow the kiln to bake the blocks.

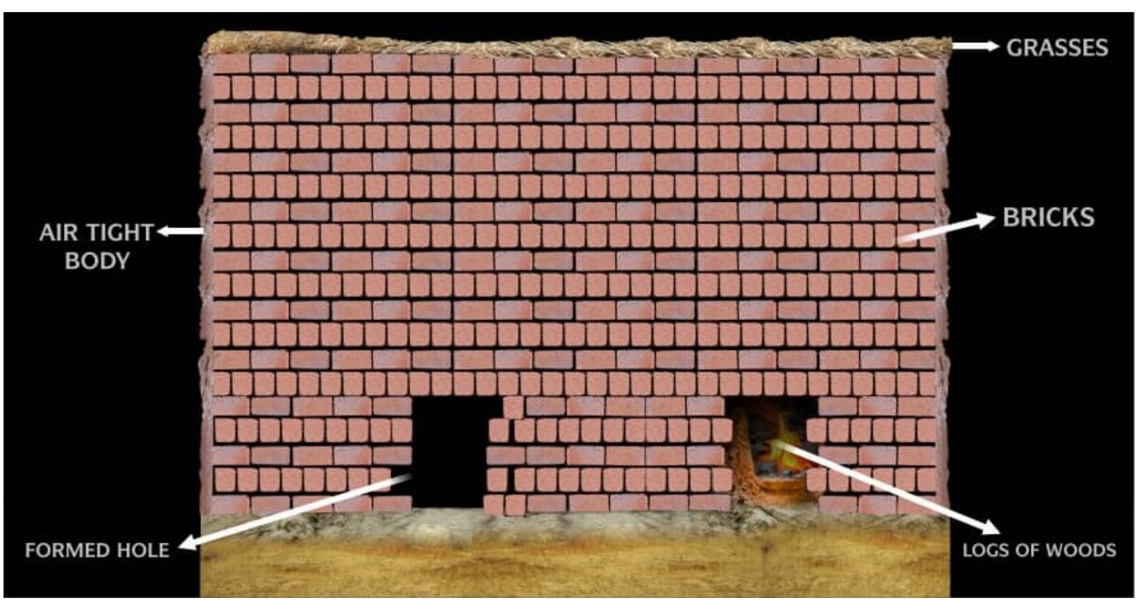

Figure 6: Cross-section of Final Kiln for Baking Burnt Bricks

Step 13: Keep the fire burning until the grasses at the top of the arranged bricks get burnt.

Step 14: Close the holes (all entrances to the tunnel) with mud and leave the burning kiln until the day it finally cools. This internal baking may take between 3 to 7 days.

Step 15: The assessment of whether the burnt bricks are strong or not is carried out by putting one of the burnt bricks inside water for at least 5 days, or trying to break one up.

At the end of these steps, the burnt bricks are considered suitable for building and other civil engineering works. In the Benue Valley region, this hard bricks are the preferable choice for constructing foundations of building in water-logged areas. It is thus common to see residential houses, churches, mosques, and parking lots built entirely from burnt bricks.

It is noteworthy that the type of soil considered most suitable making burnt bricks is clay soil. The production of bricks is not advisable during wet/rainy season for the obvious reasons. Also, logs from hard trees that do not burn away quickly are considered most suitable for heating the bricks.

The Amazing Mathematics of Burnt Bricks Production

Mathematics is the study of relationships, patterns, reasoning, numbers, and logical decision making. All these components are visible in the process of making local burnt bricks. The computational reasoning involved in burnt bricks production touches the different strands of the mathematics curriculum for basic education.

As a field of study, mathematics is the conglomeration of centuries of efforts structurally pieced together from diverse facet of human endeavour and from across different cultures around the globe (Abah, 2016). Basically, ethnomathematics is the application of mathematical ideas and practices to problems that confronted people in the past or are encountered in present contemporary culture (D'Ambrosio, 2001).

Much of what is called "modern" mathematics came about as diverse cultural groups sought to resolve unique problems such as exploration, colonization, communications, construction of railroads, census data, space travel, and other problem solving techniques that arose from specific communities (Orey & Rosa, 2006). Abah (2016) notes that modern mathematics in its present form emerged as a composite subject, with its practice and evolution deeply embedded in many successful (and sometimes, unsuccessful) human advancements.

Modern mathematics in its original form is dominated by a mechanistic teaching approach, with the subject being taught directly at a formal level, in an atomized manner, and the mathematical content largely derived from the structure of mathematics as a scientific discipline. Students are made to learn procedures step by step with the teacher demonstrating how to solve problems. This has resulted to inflexible and reproduction-based knowledge. Modern mathematics on its own in which scientifically structured curricula are used and students are confronted with ready-made mathematics is at best an "anti-didactic inversion" (Freudenthal, 1973). Instead, rather than being receivers of ready-made mathematics, students should be active participants in the educational process, developing mathematical tools and insights by themselves. It is, therefore, the goal of ethnomathematics to consider mathematics as a human exercise.

After many years of propagating mathematics so loaded with techniques, skills, as if belonging to a universe different with the arts and the humanities, modern education calls for a mathematics that can help children to grow as individuals who are noble, splendid in mind and heart (D'Ambrosio, 1994). Ethnomathematics is a response to this call. Ethnomathematics comes from the recognition that every cultural group generates its own ways of explaining, understanding, and coping with reality, transmits and organizes these ways into techniques, develops these into true recipe, and diffuses them through the group; improving and transmitting them from generation to generation. D'Ambrosio (1994) observes that consequently, every cultural group reveals distinct ethnomathematics, with some of these groups relying more on counting, measuring, and other practices. Ethnomathematics offers not only a broader view of modern mathematics, embracing practices and methods related to a variety of cultural environments, but also a more comprehensive, contextualized perception of the process of generating, organizing, transmitting, and disseminating modern mathematics (D'Ambrosio, 1992). In essence, pedagogy for modern mathematics associated with ethnomathematics take the direction of collective achievement, relying on knowledge brought by the student.

Recent decline in academic achievement in mathematics has brought more attention to cultural factors in mathematics education. D'Ambrosio (1994) observes that there are research evidences that both children and adults perform "mathematically" well in their out-of-school environment: counting, measuring, solving problems, and drawing conclusions. This category of people, mainly lower achievers in schools, is emphatically using "the arts or techniques of explaining, understanding, coping with their environment" that they have learned in their cultural setting. These practices have been generated or learned by their ancestors, transmitted through generations, modified through a process of cultural dynamics, and learned by them in more casual, less formal way. In the words of Ubiratan D'Ambrosio, "it is a patrimonial knowledge of their cultural group. It is the ethnomathematics of the group" (D'Ambrosio, 1994).

Modern mathematics is fully taking note of the complexity of factors involved in the generation of everyday mathematical knowledge. Among these factors are practices resulting from immediate need, from relations with other practices and from critical reflection. Others result from theorization about those practices, from attempts to explain and understand facts occurring in one's everyday life, as observed – to explain and to understand, to make sense of what is going on – or experienced. A careful scrutiny will affirm this reasoning as essential to theory building in mathematics education. Lakoff and Nunez (2000), for instance, acknowledge this line of thought in their phenomenal work, entitled *Where Mathematics Come From*, which promulgated the Theory of Embodied Mathematics Education. Additionally, tangible mathematics may result from playful curiosity, drawing on playful tendencies, and indeed on all sorts of cultural interest (Abakpa, Abah & Agbo-Egwu, 2018; Abah, 2018; D'Ambrosio, 1994).

Present-day mathematics education has also identified the need to reflect and embrace the cultural diversity of our classrooms, of our increasingly interconnected world (Brandt & Chernoff, 2014). By bringing ethnomathematics into the classroom, mathematics educators are empowering those whose voices and ideas have traditionally been marginalized. Presenting mathematics in different cultures can also give students a rich background knowledge, which will help them share the results created by people of all ethnic groups, admire mathematical achievements with different mathematics cultural tradition and understanding how calculating tools influence mathematics and peoples' daily lives (Zhang & Zhang, 2010).

One dynamic aspect of using ethnomathematics as a medium for modern mathematics that cannot be ignored is the storytelling context within which the teaching and learning take place (Abah, Iji & Abakpa, 2018). By connecting the topics to the students through background narratives, the ethnomathematics approach engages their emotions and helps them to understand the power of the ideas being explored, stressing the fact that mathematical tales are universal and enhance the globalization of cultural knowledge (Abah, 2017). Introducing ideas from a wide cultural background into classroom teaching of modern mathematics not only demystify abstract concepts, but foster a sense of admiration of past contributors to knowledge and build openness and global intellectual relationship in learners.

One glaring way to observe the influence of ethnomathematics on modern mathematics is a consideration of the mathematics curriculum. The diversity of mathematical practices across cultures, a diversity which, in order to challenge and supersede a monolithic and Universalist image of mathematics, is being increasingly represented in modern mathematics curricula (Francois & Van Kerkhove, 2010). Culturally adjusted mathematics education does no longer import Western curricula without further ado, but actively examines and uses local practices as an entry to the modern mathematics subject matter. Francois & Van Kerkhove (2010) observe that as a result, both a better access to mathematics education and a recognition of mathematical diversity are served. Furuto (2014) reports educational research showing a relationship between student success and an increased role for context in the curriculum, for instance, via recognition of diverse knowledge systems, use of local funds of knowledge, and the value of community understanding through social and cultural capital. Similarly, Francois and Pinxten (2013) argue that "multimathemacy", (a political agenda of ethnomathematics viewed as an educational perspective that invites the teaching of different cultural insights on counting, proportional thinking, mapping or spatial organization in preschool knowledge), should be the basis of the curriculum in order to guarantee optimal survival value for every learner. Evidently, this view is currently offering bridges between modern mathematics and cultural knowledge traditions for schooling.

Specific Instances of Mathematics in Burnt Bricks Production

Here are some specific instances of mathematics in the steps involved in burnt bricks production.

1. ***Plane and Solid Shapes:*** The wooden mould used for the making of the blocks in rectangular in shape. The inner dimensions of the mould are indicated in the diagram below:

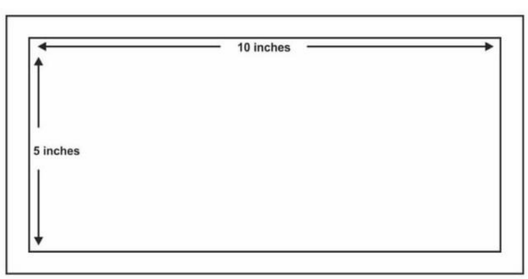

Figure 7: Rectangular Plane Shape

When viewed as a three-dimensional solid shape, the block produced by the mould is as shown below:

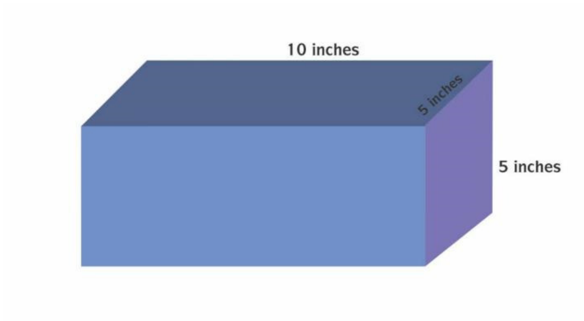

Figure 8: Solid Shape

2. ***Cost Estimation:*** The cost of the materials used in making the rectangular mould can be estimated if the thickness of the wood is known. Similarly, the cost of water, firewood and other resources needed for the production of burnt bricks can be estimated along with the number of bricks to be produced. Profit or loss can thus be evaluated if the price of one unit of burnt brick is known.

3. ***Volume:*** The heap of clay soil for the production is usually left as a huge cone. The volume of this cone can be calculated and then related to the quantity of bricks that can be produced from the heaped volume of soil. Other mensuration components can be innovatively extracted by the mathematics teacher to enrich classroom work.

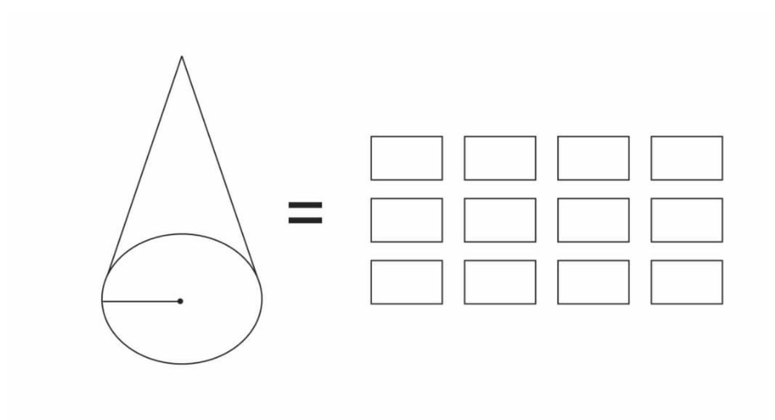

Figure 9: Volume of Conical Heap and Number of Blocks

4. ***Numbers and Numeration:*** The business of burnt bricks production is an enterprise of numbers. The arrangement of the bricks to make a heating kiln is a rich lesson in counting. Considering the number of blocks in a typical kiln, the mathematics teacher may ask students to

reason out how many of such kilns will be required to bake certain number of bricks, making necessary adjustments for defects. The number of blocks estimated for projects can also be easily worked out and even related to other raw materials used in the production.

5. **Everyday Statistics:** Lessons on record keeping can also be designed around burnt bricks production. The value chain in the business of burnt bricks production includes workers who serves as loaders of the finished products, Lorries and trucks that convey the goods from the production sites to project sites, women who fetch water from nearby streams for the production, etc. All these workers earn their living from the profits made after the sales of the bricks. Lessons in statistics may link the number of bricks corresponding to the units of inputs from each category of workers. Classroom examples and field trips can be planned by the ingenuous mathematics teacher to further enrich mathematics instruction, particularly at the Basic Education Level.

Conclusion

One of the ways the peoples of the Benue Valley derive economic gain form the natural resources of the region is the local production of burnt bricks. The craft of burnt bricks making has been passed down from one generation to the other among the numerous indigenous communities of the region. This explorative study has examined the mathematics embedded in this cultural practice. Attention has been drawn to the need to incorporate elements of mathematics found in the student's immediate socio-cultural environment into classroom activities to reduce the perceived abstractness of the subject.

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