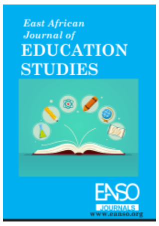

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Original Article

Mathematical Symbolization in Relation to Arts and Culture

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Constructivist, Ecological System. Mathematical Symbol, Multiple Representation.

ABSTRACT

This paper stems from an analysis of a larger study that explored proficiency in mathematical symbolization and presents students' representational fluency in using mathematical symbols concerning arts and culture. The research had the potential of revealing the conception of symbols by students, the thick line interconnection between mathematics and arts and underscoring mathematics symbols in the perspective of arts. The study objectives comprised finding out whether culture has mathematical concepts and how students conceive mathematical symbols concerning culture and traditions. The analysis made use of constructivist learning and ecological system theory as conceptual frameworks in lensing the study. The qualitative case study research design examined multiple representations of symbols among students in secondary schools and reported in light of symbols' interconnections to the perspective of the arts. The findings of the study show that students are aware of mathematics concepts and their origin in the communities' culture and prior knowledge of symbols contributes to challenges and tenacity in multiple representations of symbols in aspects of supportive and problematic conception. Discussion of these findings concerning performance in mathematics in the Kenya Certificate of Secondary Education (KCSE) may be owed to long-term negative effects on students' understanding of mathematical symbolizations which in turn could impact achievement in mathematics. The study may be useful in recommending that emphasis could be put on better ways of integrating diverse cultures in the mathematics curriculum through curriculum documentation such as textbooks to enhance mathematical symbols' conceptual understanding among students and reduce symbol cognitive load through proper pedagogical design.

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INTRODUCTION

Mathematics is one of the subjects of great importance offered in the Kenya primary and secondary schools' curricula. This has been owed to the utility attached to mathematics as a subject (KIE, 2002). However, this value was not seen to be in convergence with the performance in this subject causing the split of mathematics as Alternative A and B mathematics to give leeway to those with little interest to do alternative B mathematics that could lead to pursuing arts-oriented courses/careers. This paper brings to light the key aspects of learning mathematics known as symbolization which entails the use of symbols to communicate ideas in mathematics (Bardini & Pierce, 2015; Kharde, 2016). Mathematical concepts derive their expression from symbols which have attributable meanings and usage. Ideally learning mathematics requires a relational understanding of both concepts and their representative symbols (Moschkovich, 2008). Learners are expected to exhibit representational fluency of symbols which can be enumerated as writing, reading and verbalizing symbols. From the foregoing this may not happen solely, there could be a thick line interconnection with the cultures and traditions from which concepts are derived. The Kenyan communities are multiethnic and learning groups in the various schools consist of students from different ethnicities with different backgrounds in of terms knowledge, culture, traditions and activities involvement. This view may assist in examining how other cultures understand, articulate and use concepts and practices that are deemed mathematical (Arisetyawan et al., 2014). Looking at the teaching and learning of mathematics from a cultural standpoint may create a link between the learners' background knowledge and the formal mathematics they are to encounter in their school settings. A considerable number of researches in Kenya on mathematics achievements have been done with little emphasis on its connection with culture. For example, it is posited that mathematical language is key for conceptual understanding and achievement in mathematics (Mbugua, 2012; Mulwa, 2014, 2015) and difficulties posed by symbols to learners in mathematics have been mentioned and possible remediation brought forward. However, there has been persistent dismal performance in mathematics over the years as revealed by the Kenya National Examination Report 2020.

Table 1: KCSE Data Report 2015-2019

Year	2015	2016	2017	2018	2019
Mean Score	26.9	20.8	25.5	26.4	27.5

Source: KNEC report 2020

Statement of the Problem

Mathematical symbolization is a brief and well-articulated means of representation applicable and accepted universally in the realm of mathematics by mathematicians otherwise concepts in our day-to-day formal mathematics would be a difficult thing to put up with. Various symbols have been in use ranging from number sense and arithmetic, algebra and geometry. Symbols have origin from cultural backgrounds and knowledge whose activities are mathematically based. Conceptual understanding should be demonstrable by learners on the use of the symbols such as letters and signs and their contextual applications (Peter, & Olaoye, 2013). Mathematical symbols are cognitive actions, as they help us to represent concepts that are unimaginable with our bare brains (De Cruz, & De Smedt, 2013).

It is expected that symbols would easily assist the learners in understanding mathematics concepts and further yield better achievement. However, this is not the case in Kenya as there is still dismal performance in mathematics over the years. Mathematics learning in classrooms is met with downcast eyes (Mulwa, 2014). There is a fear of mathematics that begins at an early age and extends throughout slowing down learners' proficiency in the various mathematics classes. Jiew & Chin (2020) confirm that learners are inefficient and unable to handle symbols in revealing mathematics concepts attached to them. Consequently, learners are not able to make links between concepts and their respective symbols causing a grip on symbols use based on rules only (Nogueira de Lima, & Tall, 2008).

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In light of this, the study delves greatly in looking at the interconnection of mathematics symbols, arts and culture and ways of linking mathematics and culture taking into consideration the cultural diversity of students. Many cultures have rich artefacts that show mathematical concepts and students from various cultures come to classrooms carrying their mathematical knowledge. This is intended to address the cause for a dismal performance in mathematics in the Kenyan context.

Purpose and Objectives

The purpose of this study was to assess the conception of symbols by students and the interconnection between mathematics and culture. The specific objectives were:

- To find out whether culture has mathematical concepts.
- To explore students' conceptions of mathematical symbols in relation to culture and traditions.

Research Questions

The research aimed to answer the following questions:

- Does culture have mathematical concepts?
- How do students conceive mathematical symbols in relation to culture and traditions?

LITERATURE REVIEW

Mathematical Symbolization

Mathematics as a discipline has been making use of symbols from time immemorial both in the realist and non-realist view of mathematics. Symbolism has endeavoured to propel concepts and conceptual understanding. According to Cobb (2002), mathematical symbols are representatives of mathematical ideas, objects, concepts or processes. The representatives are related through the process of symbolisation (Godino, & Batanero, 2003). Representation being constitutive of symbolism has had great significance in both the teaching and learning of mathematics in areas such as numbers, operations, signs and algebraic expressions. Symbols manifest in attributes such as materiality, syntax and meaning where materiality refers to the appearance of the symbol, syntax is the unity between the symbol and the rules also known as the symbol system and meaning is the sense relayed by the symbol (Serfati, 2005). Moschkovich (2006) also posited that the language of mathematics stems from the symbols that comprise syntax, the symbols organization and the language of instruction. Mathematical symbolization is therefore a process that gives meaning and relationships between mathematics ideas, objects, concepts or processes and those that have been conventionally agreed upon. This may be depicted in contexts of problem-solving and multiple representations revealing levels of proficiency in individuals (Kaput & Shaffer, 2002) though there are expected challenges. These challenges may include "Polysemy symbols" – symbols with many meanings (Mamolo, 2010), different symbols representing the same concepts, 'procept' nature of symbols-symbols representing both concepts and process (Gray & Tall, 1994) and contextual meaning (Mamolo, 2010).

Mathematical proficiency in symbolization borrows a lot from some of the Kilpatrick et al., (2001) strands of proficiency specific to conceptual understanding, procedural fluency, strategic competence, adaptive reasoning and productive disposition. For the purpose of this study, the strands have been collapsed into one major proficiency which is referred to as representational fluency. Fonger (2019) defined representational fluency as a continuum of meaningful understanding of mathematics that Skemp (1976) referred to as relational understanding. This involves the linking of representation from symbolic to other representations (Pierce, & Stacey, 2004). An individual has to be equipped both in symbol sense and capacity so as to be able to create, interpret, and make meaning of symbolic representation in solving problems (Arcavi, 1994; Sullivan, 2013). This may be exemplified in reading, writing and verbalizing of symbols.

Ethnomathematics

Ethnomathematics is the perception given to mathematics from the standpoint of culture. Numerous cultures understand, articulate and use concepts which may be viewed as mathematical

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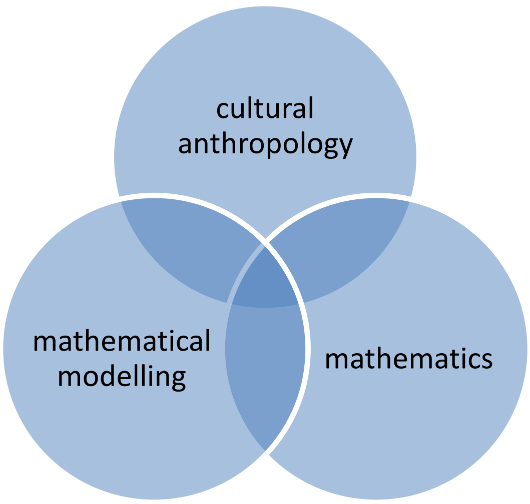
(Barton, 1996). It develops from the interaction of components such as mathematics, mathematical modelling and ethnography (Rosa, & Orey, 2013). Ethnography itself consists of ingredients that are useful in dissecting cultural unity in a given community. Such include language, technology, economic system, social organization, knowledge, art and religious system. The different social groups have their specific mathematical ideas and concepts represented in various symbols. This interconnection of the three components of ethnomathematics brings harmony during classroom instruction, though it is not the case. It is realized that the instruction strategies used do not apply local wisdom which emanates from the cultural values and knowledge.

There is a need for the inclusion of cultural backgrounds, experiences, activities and environment as components of ethnomathematics approaches in the teaching of geometry so that mathematics may not be viewed as a culturally free subject that may not need any referencing from culture. Mathematics for a long time has been viewed to be neutral and devoid of culture in it. The perception that it has no linkage to culture has ordinarily caused its learning in schools as a subject that has no concepts borrowed from culture. It was just viewed as a subject that wholly required adapting all-around acknowledged ideas, facts, and contents which is formal and Westernized. In this regard, if mathematical practices could be viewed as cultural things, then it's a product of cultural development and building relationships between a person and his or her physical and social environment. In order to respond to every question and problem arising in society there are six mathematical competencies that are common to every culture: measuring, counting, designing, locating, playing and explaining (Bishop, 1988). From the existing competencies indigenous knowledge in our communities is consistently passed on correctly to create a linkage between classroom mathematics and activities outside the classroom.

A curriculum change is expected amongst teachers to apply approaches that are learner-centered. Mathematics is an important subject for everyone; it is associated and connected to practical day life activities. Along these lines teachers ought to make a connection between culture and formal mathematics because of their exposure to mathematics ideas to ensure that learners encounter is improved through day-by-day experience inside and outside the classroom.

Figure 1: Ethnomathematics



Source: Adopted from Rosa, & Orey (2013)

Conceptual Framework

This study was guided by the constructivist learning theory by Jean Piaget and the ecological system theory by Bronfenbrenner to give grounding. According to constructivist learning theory, people develop their own knowledge and understanding of the world, through their interaction with things and

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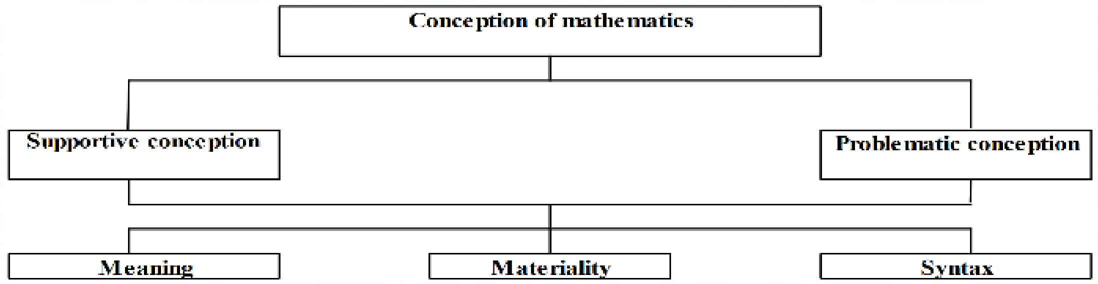
engaging in reflective practices of thinking about the encountered experiences. The experience may cause supportive or problematic conceptions. When a conception operates smoothly in both old and new contexts then it is supportive, otherwise, it is a problematic conception when it hinders progress. The conception is key to the mathematical symbolization process that may manifest according to the epistemological approach to mathematical notations. This considers that the symbols have attributes of symbol load that are dichotomized into symbol density and familiarity. This framework is anchored on the symbol familiarity that consists of materiality, syntax and meaning. In the conception of symbols, an individual must be able to recognize these attributes and the contexts under consideration (Bardini & Pierce, 2015). The conception process is affected by the prior experiences that are referred to as “met-before” (Nogueira de Lima & Tall, 2008). Therefore, the conception may be supportive met-before in case it influences knowledge development positively and problematic met-before if it influences knowledge development negatively. This depicts that conception is a dependent variable that may feature as problematic or supportive depending on context and symbol. On the other hand, symbol familiarity, syntax and meaning are independent variable as these attributes are conventional and have standard specific conception expected. Learners are therefore viewed as creators of knowledge in the perspective of non-realist mathematicians who assert that mathematical objects are created by human beings looking at the natural phenomena of interactions.

Figure 2: Conception of Mathematics and Epistemological Approach to Mathematical Notations.



Source: Adopted from (Chin, & Pierce, 2019; Jiew, & Chin, 2020; Serfati, 2005)

On the other hand, ecological system theory looks at human development within the context of the systems of relationships that form the environment (Paquette, & Ryan, 2001). This theory holds that we encounter different environments throughout our lifespan that influence our behaviour. This indicates that when we meet the right system before starting school it will impact the teaching that you will receive later in school. This study will link the system learners meet first in life and that is the culture and see how it impacts in later learning of the learner. Conventionally, there are five considerable ecological systems: micro, meso, exo, macro and chronosystems. The impact of systems institutions on individuals is illustrated in Figure 3. This ecological approach consists of components such as naturalistic paradigm, language and discourse and ethnomathematics (cultural context and mathematical activity). The theoretical model is based on the following epistemological, cognitive, and anthropological assumptions about mathematics:

Mathematics is a human activity involving the solution of problematic situations (external and internal), from which mathematical objects progressively emerge and evolve. According to constructivist theories, people's acts must be considered the genetic source of mathematical conceptualization.

Mathematical problems and their solutions are shared in specific institutions or collectives involved in studying such problems. Thus, mathematical objects are socially shared cultural entities.

Mathematics is a symbolic language in which problem situations and their solutions are expressed. The systems of mathematical symbols have a communicative function and an instrumental role.

Mathematics is a logically organized conceptual system.

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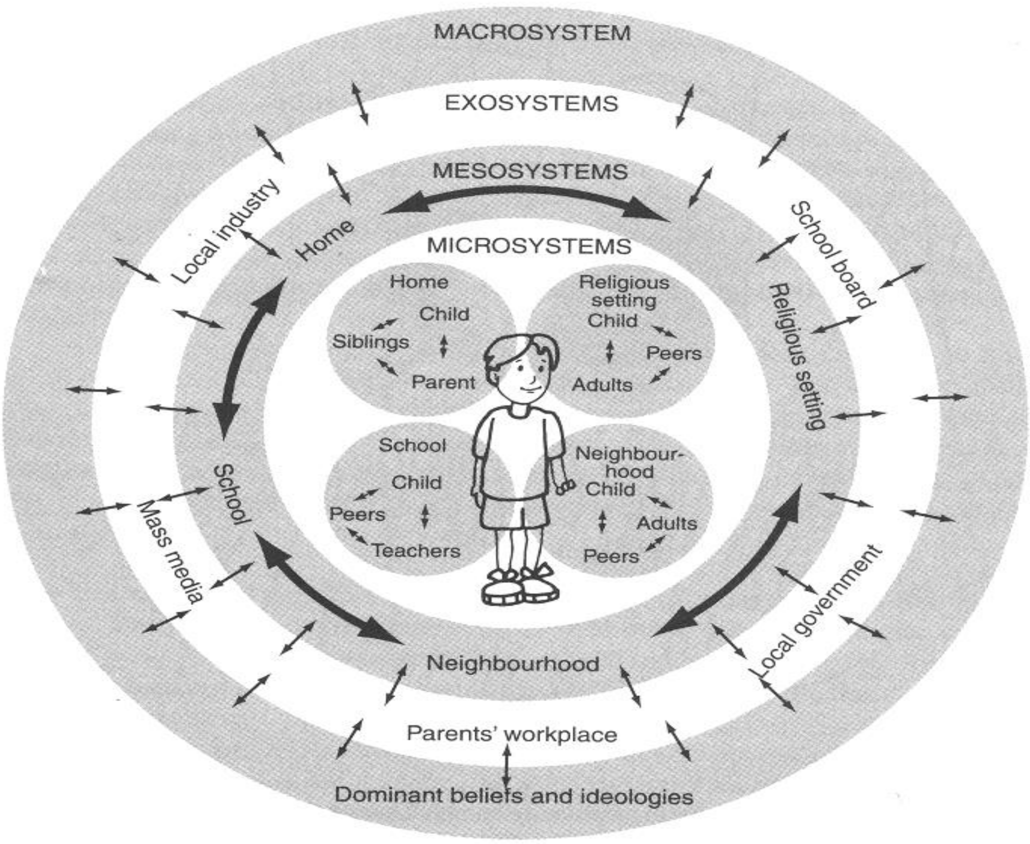
Figure 3: Ecological system.

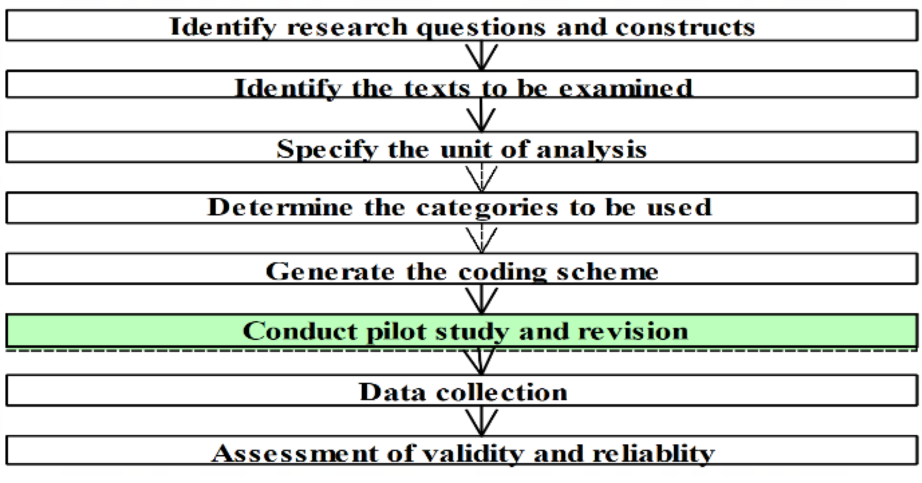


Source: Adopted from Paquette & Ryan (2001)

RESEARCH METHODOLOGY

Qualitative research design was adopted using rapid literature review and document analysis as the main approaches for data collection. Rapid literature review involved a series of articles while document analysis involved the Kenyan secondary mathematics curriculum. This was in line with two entities: culture and mathematical concepts, the conception of mathematical symbols concerning culture and traditions. A sample of 30 literature was considered for content analysis concerning the research questions posed to elicit meaning, gain understanding and reveal empirical knowledge as posited by (Bowen, 2009). This further followed the process for content analysis for secondary data as given by Harris (2001).

Figure 4: Content analysis process



Source: Adopted from Harris (2001).

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FINDINGS AND DISCUSSIONS

Mathematical Concepts in Various Cultures and Their Conception

Geometry and Measurements: The Anti-rat Technology by the Baduy Community in Indonesia

The anti-rat technology commonly referred to as geuleubeug on leuit legs has a lot of borrowing from mathematical concepts. Leuit is a room for Baduy people to keep their harvest unattended for a long time. This technology repels rats that usually eat the harvest without killing them owing to the Baduy culture of preserving the environment and nature. The wooden circle or geuleubeug on the legs of leuit make the rats difficult to climb it. This is due to the position of the rat body changing when going up from a vertical position to a horizontal position when going through the wooden circle. Because the wooden circle is quite slippery, so when the rat's body is in a horizontal position, its legs are not strong enough to stay in geuleubeug. Thus, the Earth's gravity will make the rat's body attracted to the bottom when trying to crawl horizontally. The following explanation of why the rat is difficult to climb into leuit can be explained using mathematical concepts of the vector forces acting upon the rat moving vertically. At the time the rat's body is in the horizontal position, the contact or normal force between the bodies of the rat with a wooden circle is perpendicular to the contact surface or the legs of leuit so that the normal force coincides with the weight vector. Therefore, its efforts in climbing the legs from vertical to horizontal positions are not the same. When the rat is in the vertical position, the only force to be encountered is its weight, while the rat is in the horizontal position, two forces must be encountered, those are normal force and weight. The Baduy community are practicing mathematics informally in their activities which may be borrowed and integrated in the classroom learning of mathematics.

Figure 5: Geuleubeug.

Source: Adopted from Arisetyawan et al. (2014)

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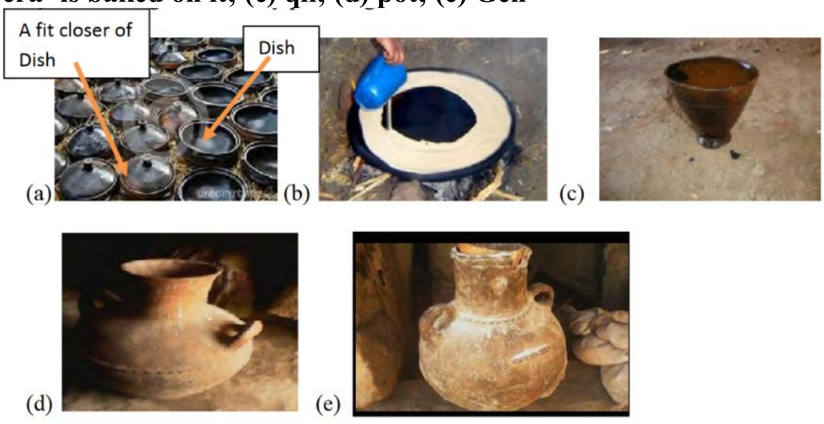
Figure 6: Leuit with Geuleubeug.

Source: Adopted from Arisetyawan et al. (2014)

Geometry and Symmetry: The Making of Pots

Some crafting occupations such as pottery making and smith in Ethiopia have been traditionally given to some parts of the community with few households until recently. The men of such a household do metal work such as jewellery, medallions, and farming instruments such as hoe and plough whereas the women are responsible for making clay pots used for cooking and preparing food and local beer. The pottery-making workplace is considered in this study. The pottery workplace is a traditional factory of ceramics with raw materials such as soil, processes such as moulding, and products such as pots. The process of pottery making starts and follows a structured cycle of phases. The potter must know the type of material to be produced and look for a special type of clay soil from a special place; this soil is milled and mixed with donkey dung and water; and hitting this mixture repeatedly with a stick until it is moulded into the shape required. This moulded shape is then exposed to air/wind to dry for 3-4 days and this dried mould is taken into the fire and ripened for at least one day to strengthen it. On the sixth day of the process, another decoration art is done by scratching and removing any rough things from both the inner and outer surface of the material using sharp objects such as broken horns or rib bones of animals or glass and using butter or oil so that the surface becomes smooth and good looking. The pots assume shapes of common solids and patterns that are repeatedly designed on the pot's outer surface.

Figure 7: Products of the pottery workplace:(a) traditional dish;(b) 'migune' with a traditional food called 'Injera' is baked on it; (c) qil; (d) pot; (e) Gen



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Geometry and Patterns: Making Baskets

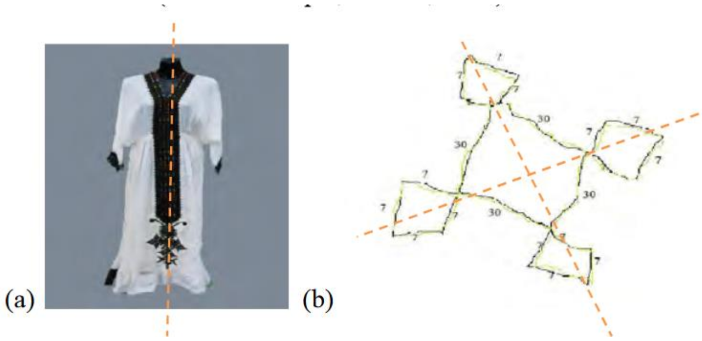
African art such as the decoration of handbags, hats, mats, and basket trays in Kenya presents the geometrical ideas interwoven in these decorations such as the area of a circle, symmetry and transformation. Figure 8 shows a basket tray that could be used to teach geometry concepts such as the area and circumference of the circle owing to its origin from the culture of the Abagusii community in Kenya (Momanyi, 2018). A teaching and learning lesson in geometry could make use of designs in the artistic decorations and connect the designs to geometrical activities in the classroom. The artefacts could make geometry real for the learners. This depicts the cultural activities that are mathematical.

Figure 8: Woven Tray Basket

Symmetry and Geometry: The Traditional Cloth Knitting Workplace

The professional practice of decorating traditional cotton cloths of men and women by putting or drawing motifs or patterns through the process of sewing or knitting with coloured threads called 'Hidyat' and needle. (Tegegne, 2015) The crafter puts the needed designs on the cloth using the colours chosen by the customer. The structure of this workplace is also cyclical with four phases. The first phase is receiving cloth and deciding what design to use. The second stage is preparation by making sure that all necessary instruments and materials such as needles, coloured threads, charcoal, and sometimes time scheduling are available. The third phase is putting the design on the cloth using charcoal or pen and then performing the actual craft of making 'tilf' according to the design. The final fourth stage is submitting the crafted cloth to the customer and collecting the service fee. The beauty of the decorations represents mathematical concepts of symmetry and sequence (see Figure 9). The design object may be representative of mathematical symbols that depict meaning.

Figure 9: The 'Tilf' design and craft: (a) Traditional cloth of females decorated by 'tilf'; and (b) a sketch of a part of the tilf



Geometry and Measurement: The House Construction

House construction has many forms. Instruments such as rope, hammer, a meter, and a hoe are used. The procedures involved start by first laying the foundations and measuring the dimensions of the house making marks by stretching a rope and then digging on the ground according to the marks and the direction of the rope. This is followed by making cobblestones in the form of rectangular prism and preparation of cement or mud. The final and third stage is building the walls of the house. The builder is tasked with the determination of the house's height, the door's height and position, as well as the position and size of the windows. A considerable number of measuring instruments for length used include 'Koriz' (hand measure which is about half a meter) and 'Tigevile' (length from thumb to middle

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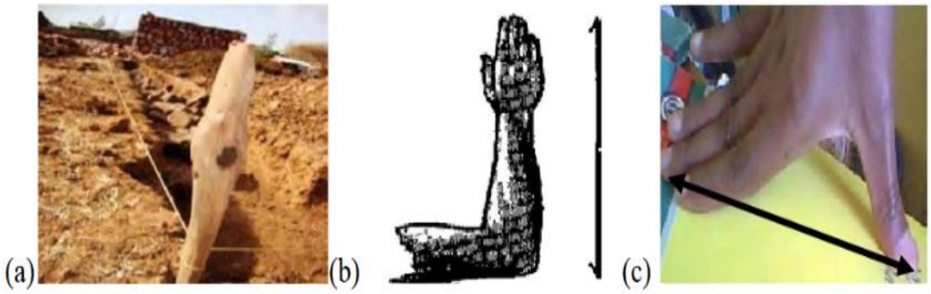
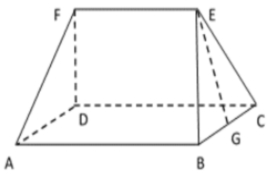
finger of stretched hand). This gives approximate measurements of lengths.

Figure 10: Measurement Instruments of Length: (a) The process of laying the base of the house in the house construction workplace, (b) 'Koriz' (hand measure which is about half a meter) and (c) 'Tigevile' (length from thumb to middle finger of stretched hand).



Source: Adopted from Tegegne (2015)

Figure 11: House Roof

Representation	Object	Mathematical Concept
The house roof is saddle-shaped or pyramid-shaped. The roof element with crabgrass as the material is the most noticeable element seen from the outside. One roof requires 100 ties of crabgrass with a tie diameter of 40 cm. 	House Roof	In determining the quantity of materials required in creating the roof, arithmetic concept is used, namely the number operation. Roof shape  Two sides are isosceles triangles, so: The area of triangle-shaped roof: L = 2(1/2 x base x height) Two sides are trapezoidal-shaped, so: The area of trapezoidal-shaped roof L = 2((AB + EF)/2 x height)

The shape of the house's walls are representatives of common solids such as cuboids and cylinders/rounded (see Figure 12) while roofs represent pyramids and cones. The quantity of materials used in construction is determinable through calculations that may be indirectly inferred from an area of the planes for walls and roofs (see Figure 11). Locations of various components of the house are strategic such as the windows, doors and fireplaces. Myriad concepts of mathematics are involved such as measurement, geometry and spatial sense.

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Figure 12: A Round Hut

Source: Adopted from Ezeife (2013)

Probability and Data Management: The 'Geveta' Game Setting in the Ethiopian Context

This is a traditional stone game common in most parts of Ethiopia. The game is made on a flat stone by digging 12 circular holes and filling each hole with four small stones (sand) or grains such as corn or peas. Two or more players can play it concurrently when each has an equal number of six or fewer holes. The play is such that a player picks all four grains from his holes, moves clockwise by putting one stone in each subsequent hole, picks all the grains from the hole he arrives and does the same until he arrives in an empty hole. On the way when this player is playing, if any previously emptied hole is again full of four grains from his territory, he will take the grains at any time. If he arrives on a hole of the opponent with three grains, he will make four by adding the grain he brought and take away and continue playing. If the first player arrives at an empty hole, he will put the grain he brought and the game is over. The winner of a particular round in the game is determined by either counting the grains one has collected and accumulated or by putting four grains in the holes and identifying who owned more holes. The player who covered more holes (houses) using these accumulated grains will be the winner of this particular round.

The "Bao" Game in the Kenyan Context

The game is very common among the communities in Kenya especially the Luo community in the western part of Kenya. The game is played on the ground or bao (wood) on which four to six holes are made on the side of the player and each three pebbles are put. The game is started by a player based on an agreement on who to start and continues in a clockwise circle until no more pebbles are left. The second player then starts and goes through the same process. The player comes to an end when one player has no more pebbles on his side.

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Figure 13: The "Bao" game among the Kenyan communities

These two games involve a lot of mathematical practices of concepts such as counting, base systems and probability.

Measurement of Capacity and Volume: Traditional Instruments of Measurement

Figure 14: Traditional instruments of measurement: (a) Beshe, (b) Tsavir, (c) Ayvir, (d) qaqa or kivi, and (e) Shirfa.

Source: Adopted from Tegegne (2015)

Measurements of capacity and volume of solid and liquid substances are measured using vessels that may not have definite and specific measuring quantity units. The context is taken from the Khimra people of Ethiopia. For example, to measure the amount of water or milk, the Khimra use 'beshe' while to measure the quantity of crops and cereals the 'ayvir', 'qaqa', and 'shirfa' of Figure 7 (c), (d), are used.

Number Sense and Numeration: Fibonacci Numbers

Mathematics studies numeric and geometric patterns which are useful in conceptual understanding of operations such as multiplication, division and fractions (Erfle, 2021). This is traceable from the nature surrounding individuals consisting of flower plants.

Flowers in the environment depict a pattern of numbers in the form of Fibonacci. Many plants have Fibonacci numbers patterns in their petals in the form of 1,1,2,3,5,8,13,21,34,55,89,144 ….

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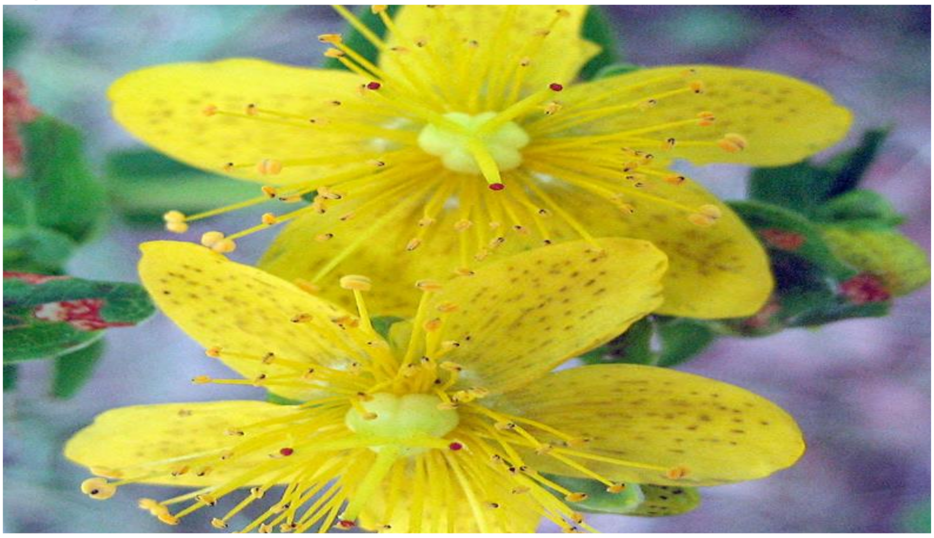
Figure 15: Petals of Flowers



CONCLUSION AND RECOMMENDATIONS

Culture has a lot of mathematical concepts. The areas that have mathematical concepts include the construction of houses, the making of pots, baskets and bao games. These mathematical concepts are in the domains such as measurement, probability, geometry, number sense and algebra. The communities are aware of the relationship between cultural activities and mathematical activities informally. Therefore, it follows that students from various communities carry their mathematical knowledge to the classrooms, proper linkage of the cultural reality of the students to the learning of mathematics (d'Entremont, 2015).

The mathematical practices from the various cultures are representatives of mathematical symbols which are the basis for learning mathematics. Therefore, prior knowledge of symbols may contribute to challenges and tenacity in multiple representations of symbols in aspects of supportive and problematic conception in the various mathematics classrooms.

There is therefore need to consider integrating diverse cultures in the various mathematics classrooms and also in the curriculum documentation such as textbooks through the use of mathematical activities that promote cultural integrity and thereby better achievement in mathematics.

REFERENCES

Arcavi, A. (1994). Symbol Sense: Informal Sense-making in Formal Mathematics. *FLM Publishing Association*, *14*(3), 24–25.

Arisetyawan, A., Suryadi, D., Herman, T., & Rahmat, C. (2014). *Study of Ethnomathematics: A lesson from the Baduy Culture*. *2*(10), 8.

Bardini, C., & Pierce, R. (2015). Assumed Mathematics Knowledge: The Challenge of Symbols. *International Journal of Innovation in Science and Mathematics Education (Formerly CAL-Laborate International)*, *23*(1), 1–9.

Barton, B. (1996). Making sense of ethnomathematics: Ethnomathematics is making sense. *Educational Studies in Mathematics*, *31*(1–2), 201–233.

Bishop, A. H. (1988). Mathematics enculturation. *Kluwer Academic Publisher*.

Bowen, G. A. (2009). Document Analysis as a Qualitative Research Method. *Qualitative Research Journal*, *9*(2), 27–40. https://doi.org/10.3316/QRJ0902027

Chin, K. E., & Pierce, R. (2019). University Students' Conceptions of Mathematical Symbols and Expressions. *EURASIA Journal of Mathematics, Science and Technology Education*, *15*(9), 1–12. https://doi.org/10.29333/ejmste/103736

Article DOI: https://doi.org/10.37284/eajes.8.1.2588

Cobb, P. (2002). Modeling, Symbolizing, and Tool Use in Statistical Data Analysis. In K. Gravemeijer, R. Lehrer, B. Van Oers, & L. Verschaffel (Eds.), *Symbolizing, Modeling and Tool Use in Mathematics Education* (pp. 171–195). Springer Netherlands. https://doi.org/10.1007/978-94-017-3194-2_11

d'Entremont, Y. (2015). Linking Mathematics, Culture and Community. *Procedia - Social and Behavioral Sciences*, *174*, 2818–2824. https://doi.org/10.1016/j.sbspro.2015.01.973

De Cruz, H., & De Smedt, J. (2013). Mathematical Symbols as Epistemic Actions. *Synthese*, *190*(1), 3–19. https://doi.org/10.1007/s11229-010-9837-9

Erfle, S. E. (2021). *Using Archimedean Spirals to Explore Fractions*. 6.

Ezeife, A. N. (2013). *Culture-sensitive Mathematics: The Walpole Island Experience*. *3*, 17.

Fonger, N. L. (2019). *Meaningfulness in representational fluency: An analytic lens for students' creations, interpretations and connections*. 5.

Godino, J. D., & Batanero, C. (2003). *Semiotic Functions in Teaching and Learning*.

Gray, E., & Tall, D. (1994). *Relationships between embodied objects and symbolic procepts: An explanatory theory of success and failure in mathematics*. 8.

Harris, H. (2001). Content Analysis of Secondary Data: A Study of Courage in Managerial Decision Making. *Journal of Business Ethics*, 191–208.

Jiew, F. F., & Chin, K. E. (2020). *Supportive and Problematic Conceptions in Making Sense of Multiplication: A Case Study*. *17*(1), 141–165.

Kaput, J. J., & Shaffer, D. W. (2002). On the Development of Human Representational Competence from an Evolutionary Point of View. In K. Gravemeijer, R. Lehrer, B. Van Oers, & L. Verschaffel (Eds.), *Symbolizing, Modeling and Tool Use in Mathematics Education* (pp. 277–293). Springer Netherlands. https://doi.org/10.1007/978-94-017-3194-2_17

Kharde, U. D. (2016). *The Symbolic Language of Mathematics*. *01*(1), 3.

KIE. (2002). Secondary Education Syllabus. *KIE, Nairobi, Kenya*, *2*.

Kilpatrick, J., Swafford, J., Findell, B., National Research Council (U.S.), & Mathematics Learning Study Committee. (2001). *Adding it up: Helping children learn mathematics*. National Academy Press. https://openlibrary.org/books/OL17062503M

Mamolo, A. (2010). Polysemy of Symbols: Signs of Ambiguity. *The Montana Mathematics Enthusiast*, *7*(2), 247–262.

Mbugua, Z. K. (2012). Influence of Mathematical Language on Achievement in Mathematics by Secondary School Students in Kenya. *International Journal of Education and Information Studies*, *2*(1), 1–7.

Momanyi, B. D. (2018). *Application of Abagusii Cultural Practices into Teaching and Learning of Mathematics in Secondary Schools in Masaba North Sub-County, Kenya*. Kenyatta University.

Moschkovich, J. (2006). Using Two Languages When Learning Mathematics. *Educational Studies in Mathematics*, *64*(2), 121–144. https://doi.org/10.1007/s10649-005-9005-1

Moschkovich, J. N. (2008). "I Went by Twos, He Went by One": Multiple Interpretations of Inscriptions as Resources for Mathematical Discussions. *Journal of the Learning Sciences*, *17*(4), 551– 587. https://doi.org/10.1080/10508400802395077

Mulwa, E. C. (2014). The Role of the Language of Mathematics in Students' Understanding of Number Concepts in Eldoret Municipality, Kenya. *International Journal of Humanities and Social Science*, *4*(3), 11.

Mulwa, E. C. (2015). *Difficulties Encountered by Students in the Learning and Usage of Mathematical Terminology: A Critical Literature Review*. *6*(13), 12.

Article DOI: https://doi.org/10.37284/eajes.8.1.2588

Nogueira de Lima, R., & Tall, D. (2008). Procedural Embodiment and Magic in Linear Equations. *Educational Studies in Mathematics*, *67*(1), 3–18. https://doi.org/10.1007/s10649-007-9086-0

Paquette, D., & Ryan, J. (2001). *Bronfenbrenner's Ecological Systems Theory*. 59.

Peter, E. E., & Olaoye, A. A. (2013). *Symbolic notations and students' achievements in algebra*. *8*(15), 1294–1303.

Pierce, R., & Stacey, K. (2004). Monitoring Progress in Algebra in a CAS Active Context: Symbol Sense, Algebraic Insight and Algebraic Expectation. *International Journal for Technology in Mathematics Education*, *11*(1).

Rosa, M., & Orey, D. (2013). Culturally relevant pedagogy as an ethnomathematical approach. *Journal of Mathematics and Culture*, *7*(1), 74–97.

Serfati, M. (2005). *La constitution de la pensee symbolique mathematique. Une etude epistemologique*. 1192–1207.

Skemp, R. R. (1976). *Relational and instrumental understanding.Mathematics Teaching. 77*, 16.

Sullivan, P. (2013). *Characterizing the Nature of Students' Feature Noticing-and-Using with Respect to Mathematical Symbols Across Different Levels of Algebra Exposure*. Pennsylvania State University.

Tegegne, H. R. (2015). *Everyday Mathematics in Ethiopia: The Case of the Khimra People*. 270.

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