MATHEMATICAL KNOWLEDGE IN ARTIFACTS MADE OF COCONUT STRAW, ANGOCHE DISTRICT.

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SUMMARY

From the 1970s onwards, the world began to worry about the quality of AEP. And the process of mathematical education in the consciousness of mathematicians needed to be adjusted in order to improve the quality of the professional training of children, and, in response to this, a technique was adopted that would allow everything that the child who attends school has learned in the community to be brought into the classroom in order to relate it to mathematical knowledge. This thinking remains evident to this day, which is why several currents are researching cultures to take their view of the world of mathematics from them. This monograph also has as its theme "*Mathematical Knowledge in Artifacts Made of Coconut Straw, Angoche District"*and its main objective is to study the cultural objects built using coconut straw by the Emákhuwa people in the district of Angoche, province of Nampula in Mozambique, as a valorization of Mozambican culture in the field of Mathematical science. Supported by several researchers in the area such as Gerdes, D'Ambrosio at the international level of Ethnomathematics research, Ossofo, Ismael, Cherinda and Banze at the national level, this work aims to recapitulate a little about mathematical practices in a Mozambican culture and bring it to the world of formal education in the country itself. In this way, the study carried out in the district of Angoche, from direct contact with the different communities, shows a general ideology of the applicability of these artifacts in the teaching of mathematics in the province of Nampula and in our country in general.

Keywords: Mathematical education process, Ethnomathematics, artifacts, Nampula

1 INTRODUCTION

In the process of scientific research there is always an obligation to propose a subject that is identified as a theme so that it can later be researched according to what was designed. This monograph has as its theme*Mathematical Knowledge in Artifacts Made from Coconut Straw, Angoche District.*In scientific research it is always necessary to identify the appropriate location for the research to be carried out. In this perspective, this research was carried out in the district of Angoche, which is 187 km from the local city of Nampula.

The district of Angoche is located in the coastal area south of the Province of Nampula between the parallels 15' and 52.9' and 16' and 21.8' in latitude South and between the meridians 39' and 54.2' and 39' and 45.2' of longitude East, bordering the district of Mogincual to the North, the district of Moma to the South, the Indian Ocean to the East and the district of Mogovolas to the West. With a surface area of 3,311 km 2, a population censused in 1997 of 228,526 inhabitants and estimated, as of 1/1/2005, at 273,073 inhabitants, this district has a population density of 82.5 inhabitants/km 2. Source (Ministry of State Administration). Education is available throughout the country.

Mathematics has brought mental discomfort to the student body, since, from the outset, students have shown themselves to be uncomfortable with what they learn in the classroom related to mathematics, particularly geometric figures, unlike real life in society. In this perspective, the level of improvement of the contents of this area of knowledge has been weak, making the pedagogical performance low in students who attended and/or are attending education in our country, with a greater focus on the subject of mathematics, as well as on the practice of activities in daily life. (Our experience in life)

Geometry, due to its wide application, plays a very important role in the education of students to solve various problems that are shared in everyday life, relating it to other fields of human knowledge, thus facilitating the improvement of traditional techniques and consequently the increase in productivity in the society where this man lives.

Straw objects made by society are related to geometry because, after the process of their construction, they give rise to geometric shapes with characteristics that are normally studied in plane geometry and space, for example when it comes to geometric figures where several concepts are involved, such as the area of a figure, volume of solids, concept of angle and other aspects.

Therefore, with the knowledge of these coconut straw materials, it is extremely important to bring out knowledge from ethnographic study to a more complex level of mathematics in people's minds, making a connection between what is acquired at school and what is learned in society, that is, uniting what they know how to do empirically in its application in mathematics, mainly for the development of skills and abilities to solve problems that concern society, since the objective of geometry is to acquire knowledge to apply and develop geometric demonstration techniques in reality.

This fact has great relevance in society, not only for its performance but also for allowing greater visibility of knowledge about geometry in the classroom, but also for allowing to solve problems in society involving volume calculation, thus effectively finding the so-called “puzzle” mathematics for the man who fears mathematics.

In the scientific sense*, “A problem is any unresolved issue that is the subject of discussion, in any field of knowledge”*(GIL, 1999, p.49). Problem, for KERLINGER (1980, p.35) cited by Gil,*“is a question that shows a situation in need of discussion, investigation, decision or solution”.*With the thoughts mentioned above, and according to SILVA and MENEZES, (2001:80) Simply put, “*Problem is a* *question that the research aims to answer. The entire research process will revolve around its solution."*

So, the author can thus understand that a problem in mathematics is when there is a question that needs to be answered and mathematical knowledge needs to be applied to find the solution that is not known. From this perspective, the study aims to make a discovery that can make it possible for students in our beautiful Mozambique who attend mathematics classes, particularly those in the coastal area of the province of Nampula, to find a real space, with ease, to practice mathematics, given that this country is rich in cultural heritage, where these, in terms of their approach to education, are becoming increasingly almost impossible, given that most Mozambican schools do not have laboratories in the areas of mathematics.

Taking the ideas mentioned above as a starting point and with some expected results from this research on the problem of teaching Mathematics incorporated into the cultural arts of that part of the province, it can be said that mathematics practitioners in that district will probably start using local materials to practice Mathematics, as they do in a certain region of the country. From this perspective of ideas, the need arises to propose the following research problem: To what extent do artifacts made from coconut straw in the district of Angoche contribute to the development of Mathematics?

From the study, it is expected that direct contact between man and cultural artefacts called: cofia, licorocho, namakokhoro, licapatja, bola, livikhelo, kelengue, lifrukho, livumbo (in the local language), made from coconut straw (Licuthi), will bring with it a very high level of knowledge in Mathematics, since the man who attends school will come into direct contact with the reality lived and known by him empirically.

In this case, when the student comes into contact with these "cultural artifacts" in math class, he begins to realize that, after all, Mathematics is present in the community where he lives, in his games, in his daily duties, and in return, he begins to have the ability to judge aesthetic values according to subjective criteria, without taking into account standards pre-established in books or by the teacher, and to apply the knowledge acquired in the classroom to his real life in the community, thus making the student more comfortable and familiar with Mathematics.

2 METHODOLOGICAL PROCEDURES

From the point of view of research objectives, this is classified as exploratory research. According to Gil (2007:43)*"Exploratory research has the main purpose of developing, clarifying and modifying concepts and ideas, with a view to formulating a more precise problem or researchable hypotheses for later studies."*The choice of this type of research was due to its objectives, since it is a study of a case that has never been researched before, aiming to provide a general view of the type of approach of mathematics practitioners to a certain fact. From the point of view of the way of approaching the problem, the Research is Qualitative.

In this study, the author sought to study cultural artifacts by focusing directly on aspects such as the geometric constructions of each artifact, thus describing the knowledge that the artifacts have related to Mathematics. Since the artifacts do not have statistical data, there was a need to conduct a qualitative study. From the point of view of its nature, it is Basic Research, since,*"the objective is to generate new knowledge useful for the advancement of science without any foreseen practical application. It involves universal truths and interests." SILVA; MENEZES, (2001, p. 21)*

When the author had access to certain artifacts and made a study of them and situated them at the level of mathematical knowledge, he can believe that he generated a series of knowledge that can bring a new vision about the teaching of Mathematics in the district of Angoche, as well as in the country in general, since these artifacts are also known in some regions of the country. From the point of view of technical procedures, it is a case and bibliographic study.

a) According to Gil (2007:72) "*A case study is characterized by in-depth study and exhaustive study of one or a few objects in a way that allows for broad and detailed knowledge."*

> According to Yin (1981, p.230 cited by Gil (2007:73),"*A case study is an empirical study that investigates a current phenomenon within its context of reality when the boundaries between the phenomenon and the context are not clearly defined and in which several sources of evidence are used."*

b) The Bibliographic study was carried out through bibliographic survey and analysis specific information about authors who address themes related to Ethnomathematics, not only in Mozambique, but also throughout the world, with the help of already published material, consisting mainly of books, periodical articles and material available on the Internet. It is obvious that when one intends to carry out any task, one needs to plan first. To do this, one must:

if you first do a general review of what are the steps, paths or situations that are well clarified to follow in order to achieve the objective previously set for that task.

In this context, the following research methods were used to obtain the research data in question: Ethnographic and Empirical. Lakatos; Marconi (2005: 112) state that *"the ethnographic method is a naturalistic way of investigating, based on observation, descriptive, contextual, open and in-depth"*.However, the use of the ethnographic method allowed observation within the community involved in the construction of coconut straw artifacts, describing and contextualizing their practices in depth, as well as structuring them around the perceptions of the subjects under study.

The empirical method is *the search for relevant and convenient data obtained through experience, from the researcher's experience. Its objective is to reach new conclusions based on the experimental naturalness of the other(s)]*[31].

Therefore, the use of this method allowed the collection of data from direct sources of people who have affection for and use the artefacts, who have experienced or are experiencing or have knowledge about such use.

From this perspective, in this work the population was represented by the population of the Angoche district, which is 273,073 inhabitants according to the Angoche district plan in the province of Nampula 2005. Some students from the Angoche Secondary School and individuals found at random on the streets participated in the study.

To this end, the researcher used techniques such as participant observation, field notes, individual and collective semi-structured interviews, structured observation data using scales, critical incidents, and photographs.

The research used the participant or active observation technique because the author made a real participation of knowledge in the life of the community and of specific situations in the same society with the aim of collecting data with greater precision, clarity and comprehensiveness.

The interview was used to understand how these are made, what material is used and what is the level of perception in relation to mathematical content. According to Gil (2007, p. 170 "*An interview is a technique in which the researcher presents himself to the person being investigated and asks him questions, with the aim of obtaining data that is of interest to the investigation."*

The interview used as a data collection technique in this research is classified as semi-structured, from which the author prepared an interview script containing some starting questions, so that throughout the research, during the interviews, he would be able to

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[31] [online] available on the Internet via www.URL:http//ptwikpédia.org/wiki/pesquisa-emp%c%adrica . Last updated on May 17, 2009.

elaboration of more questions. The following is the list of questions presented in the interview guide: Is there any information about the history of the emergence of these cultural artifacts? What types of materials are used to build the different types of cultural artifacts? How is this process of building the artifacts done? Do you think there is a relationship between the artifacts and the content studied in the mathematics discipline?

1. Explain one of them.

As previously presented, the use of field notes was to record precise and unpredictable situations during the field research. The use of scales allowed us to gather some attitudes and opinions about the mathematical vision of the case under study. Furthermore, critical incidents and photographs were used as a way to bring or even collect evidence that these artifacts were actually constructed and were collected in the Angoche district.

The use of these data collection instruments allowed the researcher to listen to the perceptions of the actors, follow them, listen to them, record them and create a portrait of a particular social situation by capturing the ways of life, cultural components, perspectives, values, attitudes, knowledge and interactions of the subjects. In this way, the researcher understood the perspectives, meanings and involvement of the subjects in a particular situation.

3 THEORETICAL BASIS

3.1 ETHNOMATHEMATICS AND ITS EMERGENCE

Mathematics emerged with the emergence of the world, since the universe created aspects around it that undoubtedly gave rise to the essential elements for the composition of mathematics. With the emergence of man and the process of developing his intellect, he began to seek technology to improve his life and consequently mathematics emerged from man's interaction with the world. Man emerged with the emergence of nature, going through several phases of intellectual development that resulted in the development of all psychic processes. In this case, we are talking about sensation, perception, thought, memorization, imagination, where with their development man also began to develop a better way of recognizing nature and consequently the discovery of a new way of representing things, in particular the objects that were being constructed by him, according to GERDES (1991:43).

> [...] By manufacturing objects of increasingly suitable shapes in accordance with his daily needs, man has learned to recognize not only the form itself and the distinction between form and material, but also the changes

> in form, whether due to their work or observed in nature: the waxing and waning of the moon, the construction of birds' nests; the centipede that curls up in a spiral when it feels threatened; a spider that makes its web, etc. The changes in form in nature now more clearly observed, can in turn lead men to new ideas and experiments.

This makes us understand that mathematics emerged from man's contact with the practices he carries out in society, and it can then be said that if Ethnomathematics is the mathematics that the community practices that is not yet formally applied in the world of education, then it can be said that Ethnomathematics also emerged with the emergence of the world and in indigenous communities.

But it was from the 1970s onwards that mathematicians, with growing awareness, felt the need to try to frame the mathematics that children bring from their community (which are the social and cultural aspects related to mathematics) in the mathematics dealt with in the classroom (mathematics education) and thus be able to efficiently accommodate the contents of mathematics in the child himself.

Many researchers in this area have published articles imposing designations on this mathematics, from which it can be said that modern mathematics was one of the first designations that Ethnomathematics took. Names such as socio-mathematics by Claudia Zalavski (1973), spontaneous mathematics by D'Ambrosio (1982), informal and oppressed mathematics, hidden or frozen mathematics by Gerdes (1982) and (1985) respectively, non-standardized mathematics by Gerdes, Coraher and Harris (1987) and popular mathematics and codified in knowledge by Mellin-Olsen (1986) are some of the names that Ethnomathematics received along its path, but it was with Professor Ubaratein D'ambriosio that the term Ethnomathematics appeared for the first time in his book*"Ethnomathematics and Place in the History of mathematics*" from which this term is supported according to MATOS (1996, p. 3):

> [...] D'Ambrósio calls Ethnomathematics the mathematics that is practiced in identifiable cultural groups, such as national-tribal societies, work groups, children of a certain age, professional classes, etc." (D'Ambrósio, 1985 b, p. 47). The same author also maintains, "Before and outside school, almost all children in the world become 'mathematized', that is, they develop the "capacity to use numbers, quantities, the ability to qualify and quantify, and some patterns of inference [...]" (D'AMBROSIO, 1985 a, p. 43).

After the designation Ethnomathematics, many currents emerged during this period, joining the previously existing currents to give a correct concept to Ethnomathematics. After several attempts, in the absence of a theory and a precise definition, D̕ Ambrósio proposed an Ethnomathematical Program. For him, it is a program believing that the methodology of the research program called Ethnomathematics should be very broad. It focuses on the generation, organization and dissemination of knowledge, and it is in dissemination that the importance of part of Education. The same author, making an etymological study of the word Ethnomathematics, gives an approximation of his thinking about his program: “it is the art or technique (techné = tica) of explaining, of understanding, of performing in reality (matema), within a specific cultural context (ethno), from where it arises according to D'AMBRÓSIO apud ESQUINGALHA (5) defines Ethnomathematics as being:

> The adventure of the human species is identified with the acquisition of styles of behavior and knowledge to survive and transcend in the different environments it occupies, that is, in the acquisition of the natural, social, cultural and imaginary environment (ETNO) to explain, learn, know, deal with (MATEMA) ways, styles, arts, techniques (TICA).

This and other contributions by Professor Ulbarataim D'Ambrósio gave a broad position to Ethnomathematics, which is today an independent science and applied throughout the world. This concept brought Ethnomathematics a deep integrity that today has become a culture for mathematics researchers to lean more towards this area of knowledge.

3.2 ETHNOMATHEMATICS AND THE PRINCIPLE OF CONTRIBUTION IN MATHEMATICAL EDUCATION

The process of human formation in family society includes the technique of teaching how to do things by doing and practicing them so that the person being taught knows how to solve his or her problems. And when the individual interacts with the community in which he or she is inserted through parents, friends and others who make up the social environment, he or she learns how to make objects that will help him or her solve those problems that require the application of Mathematics according to:

DEWEY quoted by CAPELLOTTO (p.171)*(...) the purpose of education is not to form the child according to models, nor to guide him towards future action, but to give him the conditions to solve his problems for himself.*For example, if an individual is born and lives in a fishing environment, he or she will learn to make baskets that are used to put bait in when fishing, but he or she will also learn to make other types of baskets that are used to put fish and other shellfish in, which by the way, are shaped like geometric figures. With these practices in communal environments, as well as in societies that construct mathematical ideas that have not been described in a formal way, Ethnomathematics was born, which according to D'AMBRÓSIO (1990) cited by OSSOFO (39), we will begin by defining Ethnomathematics as being “*the art or technique of explaining, knowing, and understanding mathematics in different cultural contexts.”*D'AMBROSIO thus believes that

Ethnomathematics will help mathematics itself, to transmit not only mathematical knowledge but also cultural values, living intimately with mathematics itself.

The development of the world and science has awakened people, particularly those from traditional communities, who begin to take their children to school, where they come across the teaching of geometry, which they have learned to apply in the community, but without realizing that they are applying mathematics there. This means that if the teacher teaches geometry by systematically applying the material that the student himself designs, this student can become committed to mathematics and consequently he will begin to value his culture and preserve it in a pleasant way, in harmony with GERDES (1991:b) cited by Devesse (2004, p. 8) who states, “Mozambican handicrafts can be used in the classroom, not only to improve the teaching and learning of the concept of mathematics but also to reinvigorate the culture and mathematical thinking of the Mozambican people.”

However, all research on Ethnomathematics raises some questions, such as whether the individuals who make these objects, even though they attend school, know what mathematical concepts or content are being addressed in the crafts? They say that they know nothing about mathematics and that they are just baskets or simple objects to use in daily activities and/or games, and that they learned them from their friends, parents and other people in the areas where they live. In other words, these are lessons that are passed down from generation to generation, particularly through oral tradition and participant observation, from their ancestors. This is supported by the approach of GERDES (1991, p. 22), when he states: [...]*“whether he/she wants it or not. Initially, he/she will perhaps not be aware of the idea of symmetry, but in any case the development of the concept of symmetry has already begun.”*

3.1.1 Crafts and the appreciation of culture

The concept of mathematics appears with the awakening of the world, since it arises naturally, that is, without effort or through attempts to speculate on things in nature, as is the case with the emergence of numbers, the concept of volume, height and others that make up Mathematics.

It is from this awakening that the man with a scientific vision - Mathematics, goes in search of facts that people consider as habits and customs, that is, knowledge of a certain community in its cultural environment or practices of the world in general to help awaken the mind that these habits and customs have something to do with Mathematics, but people does not bear in mind that in the process of constructing objects that are part of habits and customs, Mathematics is involved.

From a perspective of giving space to the individual who is born, grows up or also who comes into direct contact with the community, to show the knowledge brought with him through techniques learned through orality and direct observation from his ancestors and to value culture in general, giving more emphasis to its contribution to the development of science and consequently the development of the world in general and Mozambique in particular, there is a broad response to the search for knowledge of hidden Mathematics or simply Ethnomathematical knowledge that arises from the interaction of man and the natural or sociocultural environment, according to GERDES (2002, p. 220), says: "*In addition to its historical importance, continuing the study can also be useful [for]: valuing the past and present of indigenous peoples' cultures by incorporating elements of their respective knowledge, including mathematical knowledge, into teaching."*

But also including these practices in mathematics education Ubiratan D 'Ambrosio says:" *Mathematics teaching cannot be hermetic or elitist. It must take into account the socio-cultural reality of the student, the environment in which he or she lives and the knowledge he or she brings from home."*

Professor D'Ambrósio argues that children are conditioned to think that mathematics is complicated from a young age. "If they have an older sibling at home, they already hear that mathematics is difficult. It is a conditioned behavior; they enter school terrified of the subject." He says he believes that mathematics should naturally be treated as knowledge that is present in all aspects of people's daily lives. That is why he says that a pedagogy based on Ethnomathematics needs to be introduced into mathematics education. Professor Ubiratan says that a change in the educator's attitude is essential. He states that teachers who have seen that it is possible to teach mathematics by considering the knowledge brought by the student should spread this idea and pass on their experiences to other colleagues.

Ethnomathematics Research in Mozambique and Nampula Province

In Mozambique, since the 1980s, after the emergence of Ethnomathematics, there has been much research related to the area. For example, there were researchers who, up until the 1990s, published and continue to publish articles and books on mathematical research related to Mozambican ethnic cultures, which has intensified in recent years with the increase in universities in the country. Proof of this are the extensive works that have been published in the final projects of courses such as theses, dissertations and monographs.

without discarding articles published in magazines and on the internet by several other researchers in the area. This thought will be based on OSSOFO (2006:38) states that:

> Many studies conducted by some researchers in the areas of mathematics education reveal that teaching based on practical activities and Ethnomathematical exploration yields satisfactory results. And he also reaffirms that "Most of the Ethnomathematical works of GERDES (1987, 1991, 1992 and 1995) seek to exemplify the various Ethnomathematical manifestations and find their accommodations in the culture among the people who feel the reasons and need for their uses for their cultural, economic and social achievement.

Based on the ideas mentioned above, it can be stated that OSSOFO (2006) also presents a work on Ethnomathematics. In his work, he takes a raised approach to geometry and the practices of the Emákhuwa people of the province of Nampula, providing a direct explanation of the geometric configurations of this people and their relationship with mathematical didactics, from which he seeks its possible applicability for teaching mathematics, particularly plane geometry and space. OSSOFO focuses more on his work, with local material made from wood, small splinters of small trees, bamboo, clay or clay, sisal or baobab ropes and tin, although he has especially pointed out geometry and its contribution to mathematical education, which is the object of study of this research, thus there is a relationship in his results with those expected in this work, when he states in his conclusion that:

1. "*Some artifacts of the Emákhuwa people agree with the geometric shapes dealt with in the classroom and which have potential in teaching geometry"*

2. *"The nature of cultural artifacts shows the geometric configurations that can be explored didactically to teach school content as well as to teach university geometry content, especially in the treatment of analytical geometry and space in the chapter on the study of solids of revolution" (*OSSOFO, 2008:120)

On the other hand, GERDES in his works bases, but on the Ethnomathematical practices in Mozambique, where Ethnomathematical research began in the late 1970s. As most of the mathematical traditions that survived colonization and most of the mathematical activities are explicitly mathematical, that is, mathematics is partially hidden, the first objective of this research was to highlight the hidden mathematics. The first results of this discovery are included in the book On the awakening of Geometric Thought (GERDES, 1985 b, c) and slightly deepened in Ethnogeometry: cultural-anthropological contributions to the genesis and didactics of geometry (1991 a). In the book African Pitágoras. A Study in Culture and Mathematical Education (GERDES, 1992 a; 1994 b; cf. 1988 b) it is exemplified as various ornaments and artefacts

Africans can be used to create a rich context for the discovery and demonstration of the Pythagorean Theorem and related ideas and propositions. A number of earlier papers (e.g. GERDES, 1988a) are included in the books Ethnomathematics: Culture, Mathematics, Education (1991b) and Ethnomathematics and Education in Africa" (1995a). In Geometria Sona (1993-4, 1994c, 1995c, 1996b) GERDES reconstructs the mathematical components of the traditional drawings of the Cokwe (Angola) 17 and explores their educational, artistic and scientific potential (cf. 1988c). In the book Lusona: geometrical recreations of Africa (1991c) mathematical amusements are presented that draw on the tradition of sand drawing geometry. For children aged 10 to 15, the book "Living Mathematics: Drawings from Africa" (1990) was prepared. CHERINZA and BANZE (2010: 9-22) provide an overview of the initiation of mathematical research in a Mozambican cultural context using the sieve. In their book Creating the Mozambican Scientist of Tomorrow, they discuss some techniques for interlacing strips that give rise to the study of numerical sequences.

4 ANALYSIS AND INTERPRETATION OF RESULTS

This chapter describes an approach through mathematical reflection of the artefacts that were collected during the research process. There were several artefacts, but not all of them deserve the privilege of being studied, so those that are not studied in this chapter can be seen in the form of appendices.

In the data collection process, the author had the opportunity to come across various types of objects that seemed impossible to build using coconut straw, but as man is in a process of mutual development, various objects appear, with different geometric shapes, some of which do not have a name that identifies them, as can be seen at the end of this research.

4.1. GEOMETRIC CONFIGURATIONS OF CRAFTS ON THE PLAN

Nivikelo (Fan)

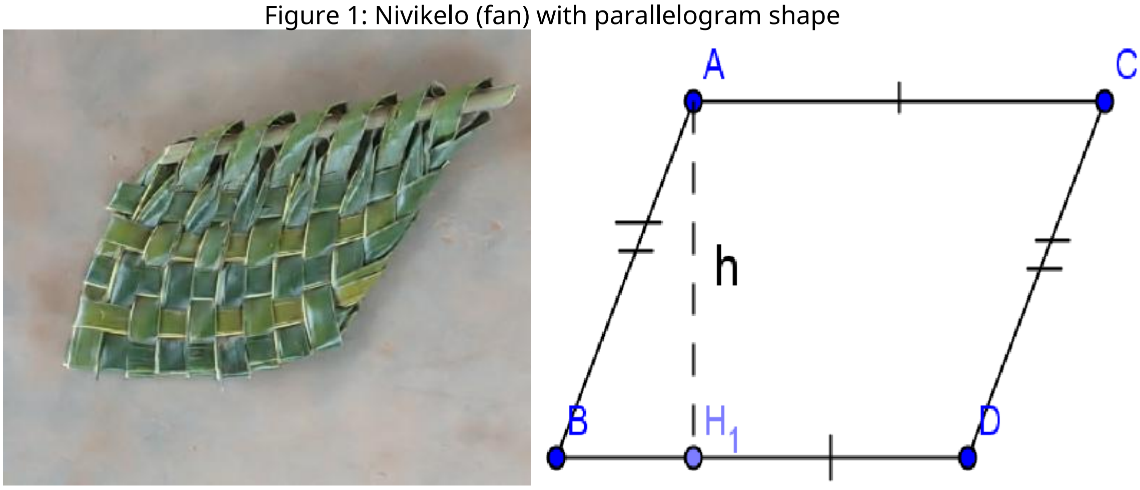
The nivikelo is an object that the Emákhuwa people of that region believe originated in the Yaruba Islands around the year 750, when one of the island's chiefs found a more viable way to light a fire in cold weather. It is an object that is still used to blow fire today. (Oral source). Its geometric configuration, as can be seen, may be a parallelogram, a triangle as well as a trapezoid as shown in the figures below respectively.

a) Parallelogram

Parallelograms are geometric figures that have pairs of opposite sides parallel. (NETO, MENDONÇA and SMITHP: 1991. Pp, 201)

In the figure below, it can be seen that it is a quadrilateral whose opposite sides are parallel and the angles and opposite sides are congruent, consequently this figure represents an oblique parallelogram.

Figure 1: Nivikelo (fan) with parallelogram shape



Source: Photo taken by the author in the district of Angoche
Source: Author's drawing

To calculate the area of the parallelogram you must find the surface that forms the figure, thus being able to say from the author's drawing that $= \_ = \times \; 1 \; = \; \times h$

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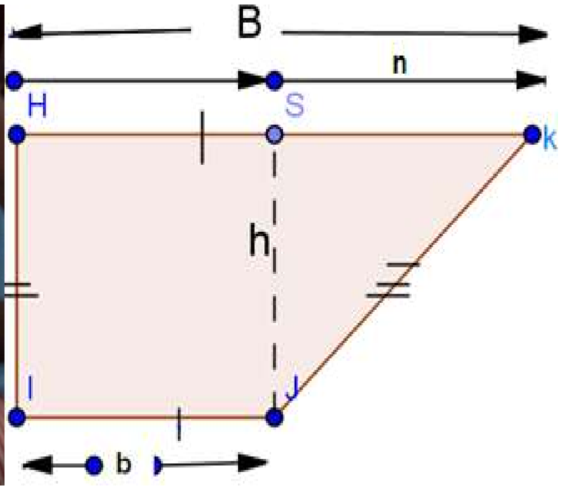
b) Rectangular trapezoid

In this figure, there is a geometric figure in the shape of a trapezoid, as can be seen in the image below. It has two parallel sides, where one side is the larger base and the other is the smaller base. In this composition, its height can be extracted.

Figure 2: Nivikelo (fan) in trapezoidal shape



Source: Photo taken by the author in the district of Angoche

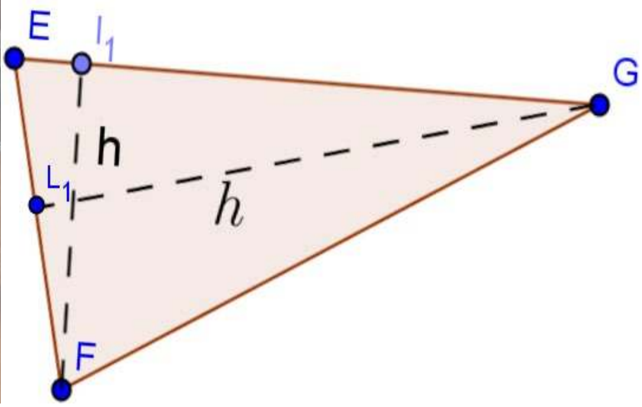
Source: Author's drawing

In a rectangular trapezoid with two right angles represented in figure 2, it can be easily decomposed into a rectangle of dimensions *b* smaller base and *h* height and a right triangle of dimensions n and h. the larger base of the trapezoid is = + ,this facilitates perception better than the area of the trapezoid is deduced in $= \frac{h(\ +\ +\ )}{2} \Leftrightarrow \ = \frac{(\ +\ )\times h}{2}$

c) Triangles

Triangles are checked in these objects without looking at the type of triangle in the classification order, that is, it is not taken into account whether the object intended is a scalene, isosceles or equilateral triangular shape. In the configuration of this figure, the author made a very important note about what is the side designated as the base of a triangle. Three altitudes can be drawn in the same triangle, as a way of making it clear that the base of a triangle can be any side as long as this, in turn, is perpendicular to the line that starts from the point opposite this same base.

Figure 3: Nivikelo with triangle shape



Source: Photo taken by the author in the district of Angoche

Source: Author's drawing

In this figure, when you want to find the area of the triangle, different bases can be used, taking into account its height, which is perpendicular to that base.

Example in this case, if we intend to use the side__ as a basis, we have to take into account that the your height could be $_1$ = h,and if our base is__ ,then it can be used as height $_1$.

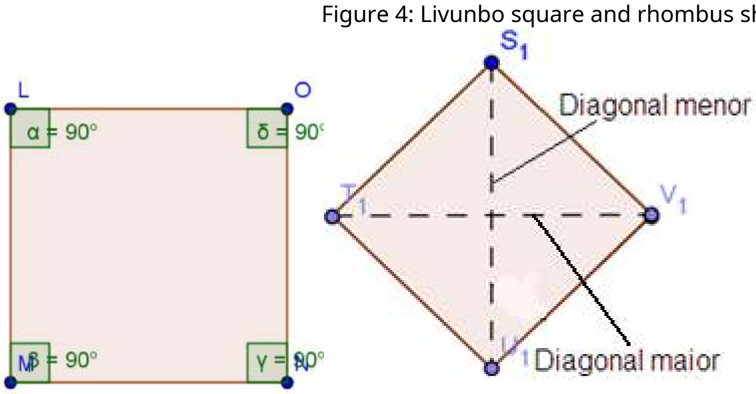
$$= \frac{\times \ _1}{2} = \frac{\times \ _1}{2} = \frac{\times h}{2}$$

Livunbo and the study of the Square

The livunbo is a cultural artifact that was once used to cover and place food. Nowadays, it is used for certain games, but on some occasions it still fulfills its original function. Its geometric configuration is a square. However, the way people position this object gives it the name “The Livunbo”, which theoretically has the shape of a diamond. This figure is formed by four equal sides, four equal angles of 90 degrees and therefore the sides are parallel two by two.

When this figure is placed with one of the vertices at the top, it can be seen that a geometric figure with two equal diameters is formed, and given the way it appears, it could be a rhombus with a larger and smaller base.

Figure 4: Livunbo square and rhombus shape



Source: Author's drawings

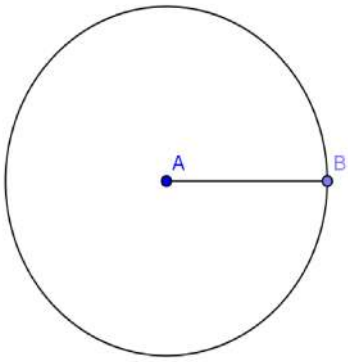
Source: Photo taken by the author (Angoche)

Namakokhoro and the study of circumference

The Namakokhoro is an object that is used as a plaything by children in that region and also in other coastal regions of the province of Nampula. This artifact in its configuration resembles a circle with a certain center, diameter and radius. On the sides it can have a frame with braids that resemble a trigonometric function of sines.

or cosines. This object can help the student find the area occupied by the circumference and also its perimeter.

Figure 5: Namakokhoro in the formation of circles

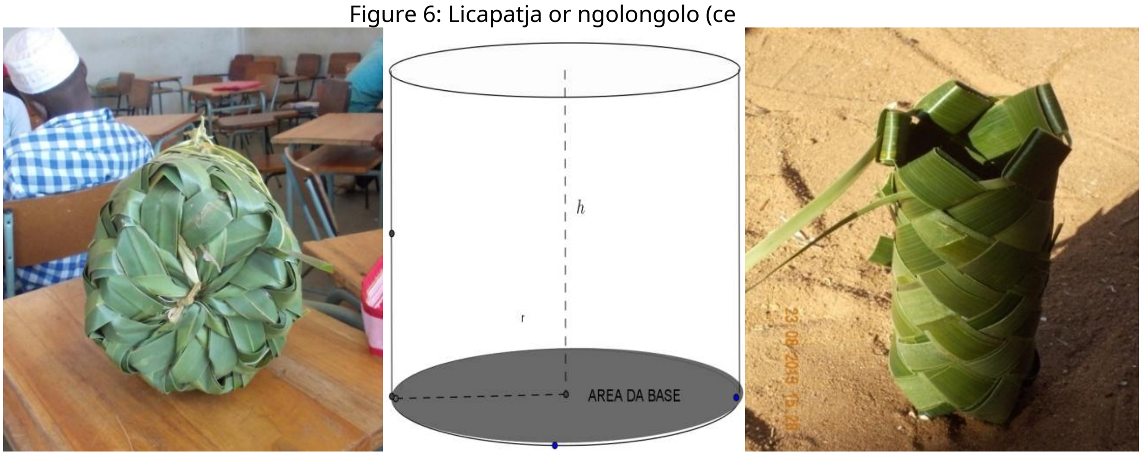


Source: Author's drawings Source: Photo taken by the author, Angoche

4.2. Geometric Configuration of Cultural Artifacts in Geometric Solids

The licapatja is a basket that is used to put food products in large quantities, which on the other hand can be called ngolongolo r and be used mainly to transport shellfish for example for family r consumption. These objects have a shape that can be used in the the areas of geometry for the calculation of volumes, and it can be , seen in the configuration of the figure below, the presence and its the respective height that will allow to formulate its volume.

Figure 6: Licapatja or ngolongolo (ce



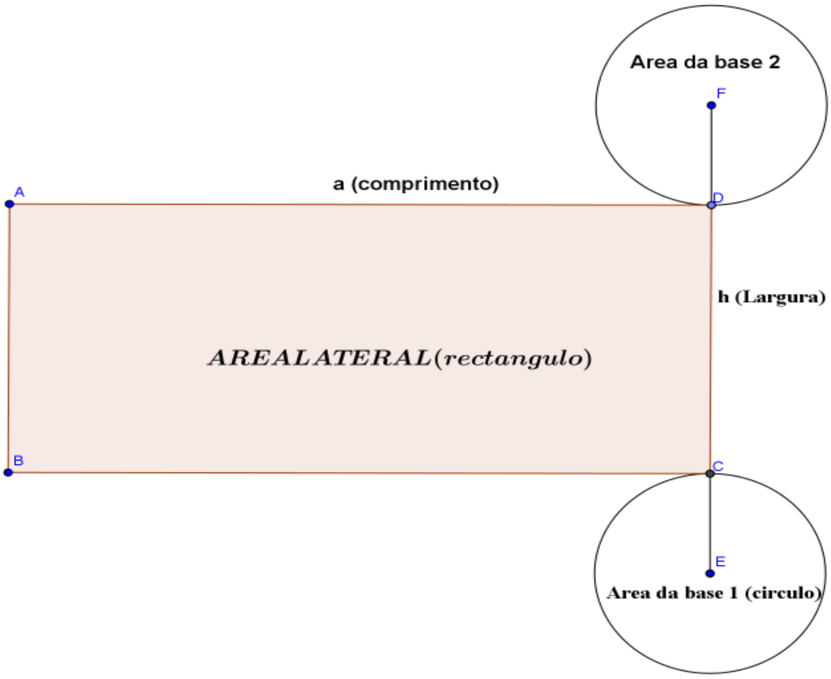
Source: Photo taken by the author, Angoche and drawing by the author

The volume of the cylinder can be shown in figure 6 and can be represented as:

$$= \quad \times h = \quad \times \quad {}_2 \times h$$

Knowing that the area of the base ( )of a solid is the area of the polygon that was taken as the base of that solid. Therefore, the study of geometric solids can be carried out below. This figure allows the student to learn how to access the total area of a geometric figure that has volume, given that, in its construction, it goes from a geometric figure on the plane and then the sides of the figure are joined, thus creating a cylinder. In this case, the student can easily understand that a cylinder has two equal bases and the lateral area that delimits it is a parallelogram and that which delimits the bases are circles and thus the total area of the cylinder can be the sum of the areas of the figures that delimit the cylinder, as in figure 7.

Figure 7: Representation of the total area of the cylinder



Source: Author's drawing

$$= \qquad + 2 \qquad = \quad \times h + 2 \quad \times \quad {}_2$$

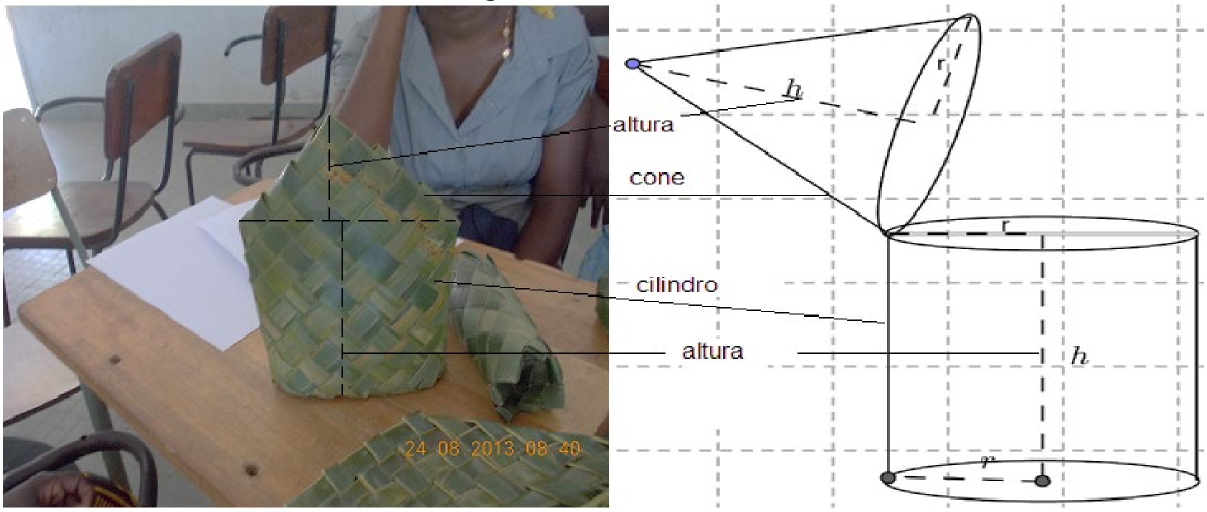
Since the perimeter of the circle is2 and is equal to the length of the rectangle in this case the base then it can also be stated that

$$= \qquad + 2 \qquad = 2 \quad \times h + 2 \quad \times \quad {}_2 = 2 \quad (\quad + h)$$

4.3.1. Cofia (Hat)

On the other hand, the existence of several different types of objects can also be verified, as can be seen in figure 8, a figure that presents a composition of a cone on a cylinder. With this figure, the student can easily understand how to calculate, for example, the volume of one figure over another. It mainly facilitates the understanding of the relationship between a cylinder and a cone, as can be seen in the figure, from where the cone can be considered to have the same height and base as the cylinder.

Figure 8: Cofia (Hat)



Source: Photo taken by the author, Angoche
Source: Author's drawing

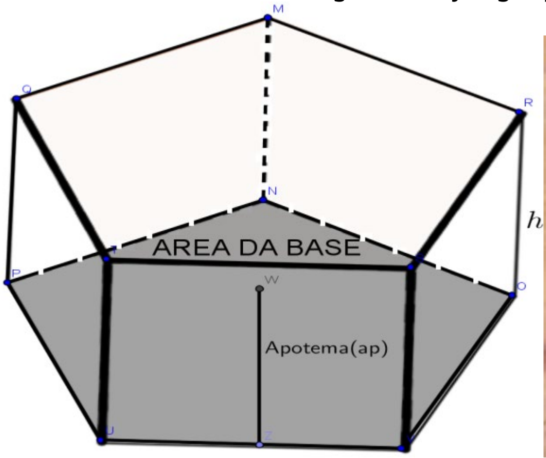
The total volume of the figure above is equal to the sum of the volumes of the cylinder and the cone, that is, as the relationship between the volumes of the cylinder and the cone is known, then:

$$= \times h + \frac{1}{3} \times h = \frac{4}{3} \times h = \frac{4}{3} \times {}^{2} \times h \quad \frac{8}{3} \times h_2$$

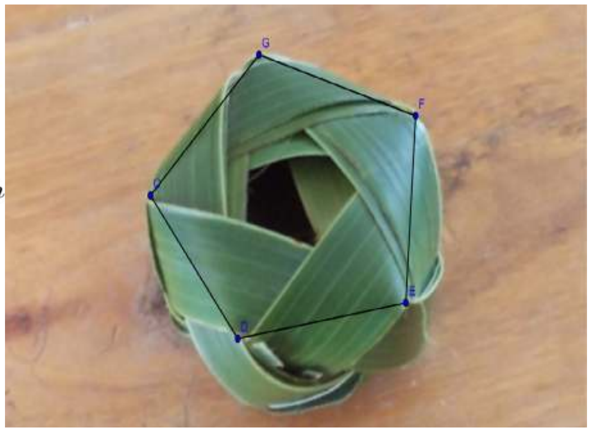
Right pentagonal prism

The right pentagonal prism, as can be seen in figure 9, has a base that is a pentagon from which its respective apothem is indicated, which is the segment of the line that joins the center of the polygon to the midpoint of any of the sides.

Figure 9: Toy (right pentagonal prism)



Source: Author's drawing



Source: Photo taken by the author, Angoche

Since the height of each triangle at the base is equal to the apothem, that is, $h =$,and since the polygon is composed of equal triangles, it can be said that $= 5 \times$.

In this order of ideas, the student can easily see that:

$$= 5 \times \quad \frac{\times}{2} = \frac{(5 \times \ ) \times}{2} = \frac{\times}{2}$$

Where: P – Perimeter of the pentagon, $= 5 \times$ $= h$ −apothem

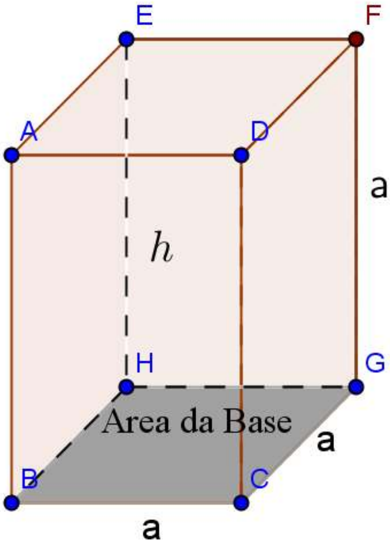
In this way, as with any geometric solid, its volume is the result of multiplying the area of its base and its height, therefore:

$$= \ \times h = \quad \frac{\times}{2} \times h$$

4.3.2. Cobblestones

A parallelepiped is a prism that has a parallelogram at its base. Since a parallelepiped is formed by the joining of the six parallelograms that make it up, this stage presents a study of parallelepipeds, which are prisms whose bases are parallelograms and can be classified as rectangles whose bases are rectangles and straight parallelepipeds, which have lateral edges perpendicular to the base. In this parallelepiped, all the edges are perpendicular to each other, it has square bases and the faces are rectangular.

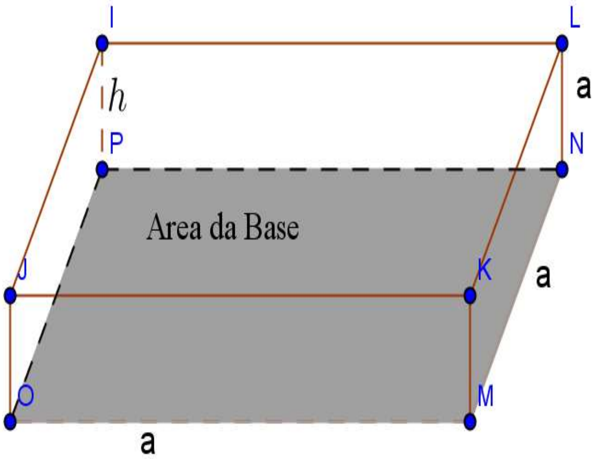
Figure 10: Box (parallelepiped)



Source: photo taken by the author, Angoche Source: Author's drawing

In figure 11, the edges perpendicular to the base are smaller in relation to the sides that make up the base, but in all cases, that is, in figures 10 and 11, the criteria for calculating the total areas of the primes do not differ since the bases are rectangles.

Figure 11: Box (parallelepiped)



Source: author's drawing Source: Photo taken by the author, Angoche

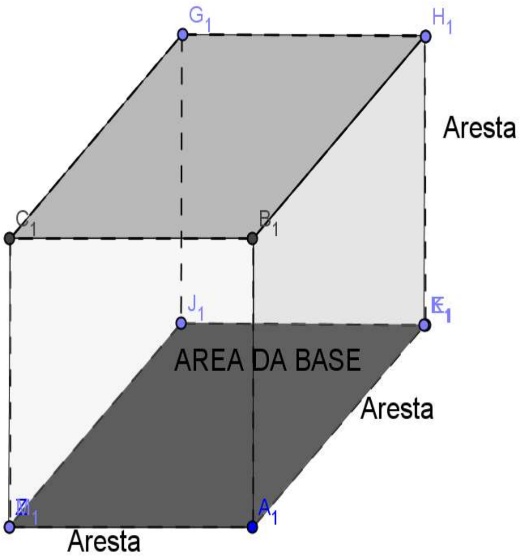
In this sense, the following formula can be presented for both figures 9 and 10:

$$= \ \times h = (\ \times\ ) \times h = \ {}^{2} \times h$$

4.3.3. Cube (regular hexahedron)

The volume of a cube is given by multiplying the area of the base by the height. Since these dimensions are equal in a cube, since it is a straight parallelepiped with all congruent edges, it can be stated that the volume of the cube is equal to the measurement of the side raised to the power of the cube.

Figure 12: Box (Cube)



Source: Author's drawing Source: Photo taken by the author in Angoche

From figure 12, as the edges are the sides of each square that delimit the cube then:

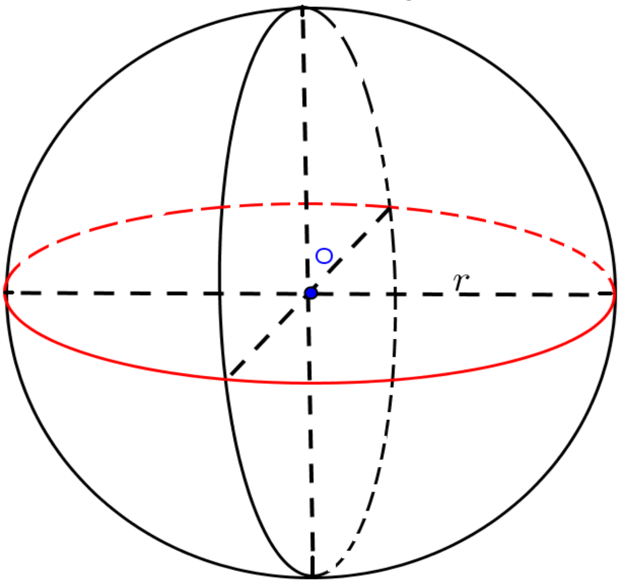
$$= \quad \times h = (\quad \times \quad) \times \quad = \quad 3$$

(Bola wa licothi) Spherical surface

According to RODRIGUES, SANTOS AND LEITÃO (2000, p. 30) “The spherical surface does not have an expression that can be easily deduced from others.” They also state “It was once again Archimedes who discovered that this area is equal to the lateral surface of the cylinder that circumscribes the cylinder.”

This way, in the image, all points on the spherical surface are at the same distance.r from the center *THE*. So, the area is four times the value of pi multiplied by the radius squared.

Figure 13: Walicuthi ball (sphere)



Source: Author's drawing

Source: Photo taken by the author in Angoche

In Archimedes' view, after several investigations, the conclusion below was reached.

$$= 4 \quad {}^{2}$$

4.3. OTHER RESULTS ACHIEVED THROUGH INTERVIEWS

Origin of cultural artefacts

Cultural artefacts in the Angoche district generally emerged hundreds of years ago on the island of Khoti and Yaruba. Some sources claim that the sources of their ancestors can be used to date the cultural artefacts back around 700 years. As is well known in the history of Africa, the economic and industrial situation of the world did not allow the use of industrialised utensils by anyone, especially those living in Africa, or even the Mozambican people, particularly in the Angoche district. At that time, the people did not have the economic conditions to obtain the few industrialised materials that came from other corners of the world for a long period of time. And with great sacrifice, they had to invent some objects that allowed them to do some domestic work as well as for sports purposes. Over time they invented some of the objects with a greater focus on the livikelo, which helped to blow the fire in the bonfire and with the passing of time the licapatja appeared to be used in the field as a basket to carry food, and others like the lifrukho, to be used in fishing as a paste to put bait in. Oral source (individuals from the Inguri neighborhood, Angoche district)

4.4.1. Process of construction of cultural objects

The construction of the cultural artifacts presented and studied in the previous figures and those presented in the appendices uses coconut straw (licothi) as its raw material. The object is constructed from coconut straw by extracting some strips of straw that serve to form the base, using a technique in which one strip passes under or over one or two others.

The construction technique for these artefacts follows a path described by CHERINDA and BANZE (2010:9) in their straw sieve interlacing technique. In this technique, a certain strip is followed over and under two strips in a perpendicular direction. The technique of interlacing a strip in artefacts made in the Angoche district is currently considered by artisans to be uncomfortable for the durability of the objects, but this factor also affects not only the durability, but also the size of the object itself, as can be seen in figures 14 and 15.

Figure 14, 15: Interlacing technique

Source: Photo taken by the author

In this process, objects are constructed based on the shapes of flat figures, and when the aim is to construct objects in space, other techniques are used based on the plane. In the construction of objects such as geometric solids, there is a very curious aspect, “the origin of 90 degree angles” through the faces perpendicular to the bases. This case is the result of the inclination of the strips in two opposite directions, that is, some downwards or upwards and others intertwining them, which in this process gives rise to the angles mentioned above.

Figures 16: Formation of angles

Source: Photo taken by the author, Angoche

After the angles are formed, you can see the appearance of faces that, with the interlacing, the gunner will calculate the height needed for the object. After reaching the intended height, with the extended strips, the curvature is made over the others, making a second path, a new interlacing to allow durability, thus forming consistent figures (figure 17).

Figure 17: Formation of the parallelepiped through the interlocking technique

Source: Photo taken by the author, Angoche

FINAL CONSIDERATIONS

In Mozambique, particularly in the province of Nampula, the teaching of plane geometry and space focuses mainly on the construction of geometric figures on the blackboard during classes. Recognizing that visualizing the blackboard helps students understand the subject, it does not eliminate the possibility of them not understanding the relationship between the subject studied and the real world in which they live. As a consequence of this, they start to study geometry to get a grade in assessments, to allow for their best pedagogical use (grades).

This situation will force this student to not see the real value of mathematics in his social life, to gradually forget the value of his culture to the world and to easily forget everything he learned during classes.

Since the artifacts discussed in this work are built by the students themselves, there are greater possibilities of their easy access and handling, since the material used does not cause economic disadvantages for the student, nor for those responsible for them, especially for the teacher who is the monitor in the classroom. In this sense, the study of these artifacts leads to the following conclusions:

1. The process of construction of cultural artifacts made of straw in the Angoche district allow for a broad study and offer broad development for mathematics;

2. Cultural artifacts made from coconut straw in the Angoche district allow make a deep interpretation of geometric figures on the plane and in space and has enormous didactic potential for teaching geometry in schools in the province of Nampula and in the country in general;

3. Using local materials made from coconut palm straw, math practitioners They will easily understand the content and practice Mathematics naturally in the district of Angoche.

4. The artisans of these artifacts have a notion of geometric figures and solids. incorporating its elements of angle, volume and size despite using this knowledge in an empirical way.

As is known, in order to obtain good results, necessary and sufficient conditions must exist, such as geographical, economic and social conditions. This work describes, with limitations, the following situations:

1. Lack of financial conditions to carry out a study covering all neighborhoods and localities in the district of Angoche;

2. The scarcity of bibliographies related to the area also influenced the interpretation of the research results.

3. Lack of specific software for constructing geometric figures in space conditioned the analysis and interpretation of artifacts, generating great discomfort on the part of the researcher.

From the perspective of the researcher and author of this work, the following recommendations are proposed: 1. Education stakeholders reformulate teaching plans in such a way that to include the cultural artefacts of the Emákhuwa people of the Angoche district in the teaching of geometry in the Mathematics discipline;

2. The actors in the classrooms (teachers) use local material to improve the quality and use of mathematics teaching, particularly geometry;

3. As the research cannot be considered finished, it is recommended that further research be carried out other studies on site or in other regions of the country to allow greater veracity of the conclusions of this work as well as to search for new knowledge that was not focused on the artifacts.

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