Mathematical Structures of Woven Bamboo Crafts of Lagangilang, Abra, Philippines

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Abstract: Bamboo is one of the most substantial forest product in Abra. It has been used by Abrenians as a building material, a source of food and in making woven crafts. Hence, this study sought to identify the mathematical concepts, shapes, and designs present in the woven bamboo crafts; determine the mathematical structure of their patterns; and associate meanings and mathematical implications of the designs. Data were gathered through an interview from the weavers of Lagangilang, Abra, Philippines. The descriptive method of research was utilized for the analysis and interpretation of data. The patterns were analyzed through the enlacement of bamboo strands that emphasized the structure and design of the woven bamboo craft. It was observed that the most of the crafts have a tessellated base. Geometric transformations like translation, reflection, glide reflection, and rotation are also present in the products. Moreover, mathematical patterns from the Frieze Group were also obtained. Mathematical structures exist in the weaving pattern of the bamboo craft products in Lagangilang, Abra, Philippines. Hence, these are evidences of systematic mathematical representations in the modern world.

Keywords: Bamboo, Woven Crafts, Mathematical Structures, Patterns, Abra.

Introduction

Bamboo is a multipurpose plant that has productive, aesthetic, and protective functions. Bamboo could provide livelihood options, beautify landscapes, and protect the environment [1]. It has been used for many applications and supported many major industries such as housing, construction, handicraft, furniture making, and food production [2]. The use and trade of bamboo have been growing rapidly in recent years. It is becoming popular as an excellent substitute for wood in producing paper, board, pulp, and charcoal. It is used widely either in its natural form or as a reconstituted material [3].

Bamboo plays an essential role in the daily life of people in the subtropical and tropical regions,[4] and widely used by indigenous people [5]. Products from bamboo are traditional products in the Philippines. A variety of bamboo products are already crafted and sold in the domestic and export markets. It has benefited many local industries and contributed a lot to the culture, tradition, and economy of the community.

Weaving is an ancient craft in the Philippines. It occurs among more sedentary societies where farming features as their main source of livelihood. Weaving and textile production is generally absent amongst traditionally nomadic societies or communities that are heavily oriented towards wild forest resources and where domestication of animal for food is absent [6]. Basketry and weaving are generally women activities [7]. However, nowadays, men also weave. Basketry knowledge are well transmitted while others are not. Incomplete transmission can give rise to new forms of interaction between idiosyncratic ‘know-how’ and customary knowledge, leading to innovation and improvisation [8].

Abra has been engaged in bamboo weaving like any other province in the Cordillera, which is home to a diversity of plants matched with equally rich culture[9]. The celebration of the founding anniversary of the province known as the “Kawayan (Bamboo) Festival” portrays the importance of bamboo to Abrenians. Bamboo has become a popular material not only because it is available and easy to process but also because of its relative durability and low cost [10]. Most of the woven crafts in the province are hats, baskets, fans, and furniture. These products are known for their unique and artistic designs. The craft portrays various designs, patterns, and symmetries which are evident through their
mathematical structures. The weaving patterns were studied to show that Mathematics is embedded in the Abrenian culture.

The figure below represents the paradigm of the study:

![Figure 1: Research Paradigm](image-url)

The paradigm shows that from the basic concepts of mathematics and through interview, observation of the weaving process, and analysis of weaving patterns, mathematical structures of the patterns of the woven bamboo crafts were illustrated. These features were seen in the woven bamboo crafts of Lagangilang, Abra, Philippines. The loom woven cloth of Abra presents many geometric concepts such as lines, parallel lines, intersecting lines, planes and polygons and transformations which are symmetry, isometry by translation, rotation, reflection and optical art as illustrated in the different designs and patterns [11]. Also, algebraic structure exists in the weaving patterns of the Ilocanos which indicate a systematic representation of an indigenous artwork. Moreover, the woven fabrics contain patterns belonging to five of the seven Frieze groups. These groups are the following: F1 (translation), F11 (reflection and translation), F12 (two reflections), F21 (three reflections) and F22 (reflection and half-turn), an indication of the very creative skill of the Ilocanos [12]. Further, the algebraic structure of the weaving patterns of the Kankana-ey, a cultural minority group in Mountain Province, obtained twenty patterns from six groups of Kankana-ey fabrics. These patterns belonged to four out of the seven Frieze-groups [14].

**Statement of the Problem**

This study will contribute in developing a more relevant and responsive curriculum in Mathematics. The research outcome will provide bases in the preparation of mathematical instructional materials, which address the industry, and culture of the Abrenians. It will also show practical applications of Mathematics in the cultural aspects of the community. Usage of indigenous materials makes learning more interesting and meaningful. It promotes an awareness and understanding of the unique characteristics that depicts the culture of a group of people. It will be contributory to the expanding literature on Ethno mathematics. This is to begin the recognition and appreciation of mathematical ideas to every people, value their knowledge in different ways, and use of such knowledge as the starting base in Mathematics education.

Hence, this study sought to identify the mathematical concepts, shapes, and designs present in the woven bamboo crafts; determine the mathematical structure of their patterns; and associate meanings and mathematical implications of the designs.

**Method**

**Research Design**

This study adopted the descriptive method of research. It is descriptive because the study tried to show the applications of mathematical concepts to the different bamboo crafts produced in Lagangilang, Abra, Philippines. Moreover, it is descriptive because it discussed about the different mathematical patterns that were analyzed through the interlacement of the bamboo strands. It gives an additional mathematical knowledge which the patterns and designs of the bamboo craft implies.

**Research Respondents**

The respondents of the study were the bamboo craft manufacturers in Dalaguisen Lagangilang, Abra, Philippines. The respondents are among the pioneers in bamboo craft production in the municipality.
Data Gathering and Analysis

Observation of the weaving process

Photos were taken as the weavers worked on the bamboo crafts. Casual interview was administered to the weavers who served as the key informants. Mathematical concepts present in the bamboo crafts were determined. The mathematical implications of the woven bamboo crafts were decoded as the weaving process went on. The observation of the weaving process and the finished product was done to escalate the decoding of the information gathered.

Illustrations of the mathematical patterns of the woven bamboo products

Collected information was decoded. The patterns were analyzed and illustrated mathematically thereafter. The mathematical groups of patterns were adopted to determine the mathematical structures of the woven bamboo craft.

Results and Discussion

Mathematical concepts, shapes, and designs present in the woven bamboo crafts

The succeeding diagrams illustrate the woven bamboo crafts in Lagangilang, Abra and how mathematical concepts are applied and associated in these products.

Plate 1: Weaving process of bamboo craft base in Lagangilang, Abra

Plate 1 shows the process of bamboo weaving which starts with the laying of the bamboo strip vertically called the weft. The vertical strips should be at equal distance and parallel to each other. The bamboo craft manufacturer starts to weave the base perpendicular to the laid bamboo strips, which is called the warp. The bamboo strips are considered as lines. After the base is done, the bamboo craft manufacturer uses some thinner bamboo strips to make embroidery at the point of intersection of the weft and the warp.

Checker work, wickerwork, crossed weft, and diagonal or twilled are the most common types of weaves. In the checker work, the warp and weft are of uniform size and pliability. The warp and weft passes over one and under one of the other, thus forming square or rectangular checks. A variant of this weave is found usually in certain baskets in which the warp is crossed and the weft passes through irregular order, so as to produce hexagonal openings. In wickerwork the warp is rigid; the smaller and more flexible weft passes under one and over one of the former. In crossed weft, two sets of wefts cross each other at an angle and interlace arigid warp. Diagonal or twilled weaving is particularly common. It occurs when two or more weft strands pass over two or more warp elements, but not the same in adjoin in rows also warp and wefts both run diagonally [14].

There were specific and appropriate number of bamboo strands that were used in each product. The kitol (Plate 2) used 90 bamboo strips for the body/weaving, 10 strips for the base and 24 strips for the embroidery; the plate (Plate 3) is composed of 100 bamboo strips for the body/weaving, 12 strips for the base and 26 strips for the embroidery; the triple lips (Plate 4) is composed of 86 bamboo strips for the body/weaving, 8 strips for the base and 16 strips for the embroidery.

Plate 2: Kitol
The rectangle (Plate 5) is composed of 110 bamboo strips for the body/weaving, 13 strips for the base and 27 strips for the embroidery; the boat shape (Plate 6) used 90 bamboo strips for the body/weaving, 12 strips for the base and 24 strips for the embroidery; the oval (Plate 7) is composed of 100 bamboo strips for the body/weaving, 112 strips for the base and 28 strips for the embroidery.

The tray (Plate 8) is composed of 90 bamboo strips for the body/weaving and 10 strips for the base; the bamboo star (Plate 9) composed of 90 bamboo strips for the body/weaving and 10 strips for the base; the basket (Plate 10) used 90 bamboo strips for the body/weaving, 10 for the base and 22 for the embroidery.
Plate 9: Bamboo Star

Plate 10: Basket

Plate 11: Heart Shape

Plate 12: Sewing Kit

Mathematical concepts such as the circular region are evident in the kitol, plate, triple lips, tray, bamboo star, basket, and sewing kit. Oblong, star and heart shapes were also obtained and these were illustrated by the oval, bamboo star and heart shape, respectively. Moreover, squares and rectangles were shown in almost all the crafts’ bases. Mathematical concepts were applied like division to attain balance. The strands in one weaving procedure were considered as lines. Also, the strands featured parallel lines [11].

The woven bamboo crafts illustrate the designs possessed by every craft produced in Lagangilang, Abra. Unknowingly, the woven bamboo crafts revealed repeated designs. This is done by repeating the process of weaving. The weavers were not aware that in every woven bamboo craft there exist a corresponding design and art. Many craftsmen have actually used mathematics in a very real if intuitive sense, usually without the appropriate mathematical tools [15].

Further, due to the absence of color combinations, the designs were not easily noticed. If two different-colored strands were used, the design will be further emphasized.

Tessellation was also evident on the woven bamboo crafts. Rectangle, square and parallelogram were exposed repeatedly in those products.

Mathematical Structure of the patterns of woven bamboo crafts

The succeeding plates illustrate the derived patterns in each of the woven bamboo craft.
Plate 13: Reflection of figures on a woven bamboo craft

Plate 13 shows a horizontal line of symmetry $L_1$, a vertical line of symmetry $L_2$ and a diagonal line of symmetry $L_3$. This implies that there is a reflection of figures on the base and on the body of the craft horizontally, vertically and diagonally. This geometric transformation is evident on the following woven bamboo crafts: kitol, plate, triple lips, rectangle, boat shape, basket, oval, heart shape, and sewing kit.

Plate 14: Dilation of the Star on a woven bamboo craft

Plate 14 shows the dilation of the star at the center of the woven bamboo craft named bamboo star. A dilation is a transformation that produces an image that is the same shape as the original image, but of different size. Further, it stretches or shrinks the original figure.

Plate 15: $F_{12}^3$ Group on a woven bamboo craft

The pattern on the crafts’ base except the bamboo star, has two reflections about two lines $L_1$ and $L_2$ as illustrated in Plate 15. Hence, the weave belongs to the $F_{12}^3$ group. In this pattern, there were no rotational lines of symmetry that was represented by a subscript 1. There were two vertical lines of symmetry which was represented by a superscript 2. This is similar to the checkered pattern in which there were vertical lines of symmetry along two successive strands of the bamboo craft [12].

Plate 16: $F_{13}^3$ Group on a woven bamboo craft

Among the patterns uncovered, one belongs to the $F_{13}^3$ Frieze Group which is described as the combination of reflection and translation. In Plate 16, there was no rotational line of symmetry. However, there was a horizontal line of symmetry and a vertical line of symmetry. The generator of the pattern is a reflection about line $L$ and a translation $t$. There is only a translation of the design. This pattern is evident on the body of the crafts.

Meanings and mathematical implications of the designs of the woven bamboo craft

The woven bamboo crafts showed geometric transformations such as reflection and dilation. For reflection, if we draw a line of symmetry horizontally, vertically, and diagonally through the
center of the base of the craft, a reflection of the figures is obtained. This geometric transformation is evident on the kitol, plate, triple lips, rectangle, boat shape, basket, oval, heart shape, and sewing kit. Dilation is evident on the base of the bamboo star where the star at the center of the craft is being transformed in an image that is the same shape as the original but of different sizes. The tray base perceived to represent a domino tessellation. This implies that the craft possess only one regular polygon which is the rectangle.

Furthermore, a monomino tessellation was shown in the base of the crafts wherein it featured squares and it used only one color of strand. This is the simplest of the three basic textiles. This design was obtained due to the over and under process of weaving. Two strands in perpendicular directions interweave to create a single design of the same size.

These designs manifest that one need not to be knowledgeable of mathematics specifically geometry to come up with a beautiful output.

Conclusions

Different mathematical concepts such as geometric figures were utilized in the creation of woven bamboo crafts. Also, a monomino tessellation was revealed in this study. The result of the study showed that an algebraic structure existed in the weaving patterns of the town folks of Lagangilang, Abra and obtained two out of seven Frieze Group and these are: $F_3$, or glide reflection, and $F_2$ or two reflections a and b about line $L_2$ and $L_3$.

References

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