

## Ethnomathematics on Pandan Mat Weaving Art at Kolej PERMATA Insan

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### ABSTRACT

*Kelarai is defined as a damdam-shaped pattern mat that comes from the word “dam” which is known in Malay as a chess board that refers to a rectangular pattern. Designing the Kelarai pattern in this mat weaving is not as easy and requires mathematical skills to ensure a consistent design. In Mathematics, rotation, reflection, translation, and enlargement are types of transformation concept to make some changes on any given geometric shape. On the other hand, tessellation is generalized to higher dimensions and various geometries that covers any surface using geometric shapes with no overlaps and no gaps. In this research, a pattern of Kelarai named Kepala Gajah was determined and compared between combined transformation and a single transformation with enlargement. Besides, the concept of tessellation was analyzed on this pattern. The main objective is to determine whether its pattern is compatible with the concept of transformation and tessellation. The uniqueness of this pattern can be seen when the final image under combined transformation and single transformation with enlargement remains the same result. Meanwhile, the shape of an elephant's head woven in a square shape without any overlays and gaps proved the tessellation concept that was applied on the pattern.*

**Keywords:** Ethnomathematics, Kelarai Kepala Gajah, Transformation, Tessellation, INAQ gifted education

## 1 INTRODUCTION

Mathematics is an art that includes forms geometry that is processed and varied to produce an interesting pattern and perfect as mentioned by Ismail and Atan [1]. Anuwar [2] said that the application of mathematical skills has long existed among activist's art, so many geometric shapes are used as a reference to produce beautiful and symmetrical combinations of motifs and patterns. Salleh [3] amplified that the object is said to have properties symmetry if each part of the object, which is the result of division the point, line or plane that is made the center or axis of the object, consists of similar parts.

Symmetry is a transformation that allows the objects or the pattern to remain unchanged by maintaining the order of the original shape and size of the motif the reversal process occurs on a plane strip [4]. The basis of repetition to produce symmetrical patterns are through translation, reflection, rotation and sliding reflection.

According to Sulaiman *et al.* [5], the pattern and motifs in Malay artworks are rich with mathematical values which can be seen on any geometric designs. Their mathematical thinking was born in culture and value system of a race or ethnicity. Furthermore, the combination study of these two aspects, which is culture and mathematics, is known as Ethnomathematics [6]. Ethnomathematics is defined as mathematics that is built along with a society's value system, culture, and outlook on life. This means that mathematics value is supported by the science of mathematics itself and the culture of society where mathematics is taught and developed. Ismail *et al.* [7] said that it connects culture and mathematics from various aspects namely art, literature, religious education and thought.

Malay art includes the creation of carving art, weaving art, painting, architecture, and textile art. It proves that the Malay community has high thinking power in the production of art. Mathematics concepts on the artwork can be seen through the meaning implied through the composition and pattern delicate and artistic. It can be seen in songket weaving, mengkuang weaving, art carpentry, wood carving and other arts. Rahman *et al.* [8] were making clear where artistic production requires skills, creativity, thinking and knowledge in relation to nature life.

Geometry is one of the three decorative motifs in Islamic art that does not use figures other than calligraphy and Arabic motifs. Geometric motifs in Islamic art use the method of repeating basic shapes such as squares, triangles and circles which can eventually produce very complex and impressive patterns [9].

Geometric motifs in Islamic art are often found in the production of handicrafts, architecture, ceramics, and carpets. In traditional Malay society, the geometric patterns in Islamic art are often produced through the manufacture of daily items such as mats, baskets and pottery as the geometric patterns have their own uniqueness and attractiveness.

The geometric design of the Malay nature usually applied in the art of weaving. Malay weaving art has a decorative technique known as Kelarai, where it is defined as a damdam-shaped woven pattern. The name comes from the word "dam" which refers to a rectangular pattern known in Malay art as a chess site. Woven is the skill of weaving leaves such as mengkuang leaves (*Pandanus artocapus*), sea pandan (*Pandanus tectorius*), rattan (*Calamus peregrinus Furtado*), oil bamboo (*Bambusa vulgaris*), or giant bamboo (*Dendrocalamus asper*) [10].

According to Idriz and Ibrahim [11], there are three types of natural elements used to produce the pattern of Kelarai which are flora, fauna and abstract. The element of nature has become a source of ideas for weavers to style images of fauna, such as birds and animals. They also use flora such as plants and flowers as sources of motifs. Some motifs are inspired by abstract elements such as cosmology and names of prominent figures [12] and [13].

Designing the Kelarai pattern is not as easy as it seems as it requires mathematical skills to ensure a consistent design. Weavers need to master three key skills to produce the Kelarai design, where they need to shape the pattern creatively, able to calculate the weave angle and arrangement of the colors, and efficiency and precision in weaving to ensure that weave overlays are done consistently.

Ahmad and Idris [14] proved that there are three common Kelarai pattern designs among the Malay community which are flora (*bunga cengkeh, bunga pecah lapan, bunga cempaka, bunga durian, bunga tanjung, beras patah, cengkeh beranak*), fauna (*tapak anjing, tapak harimau, mata bilis, kepala gajah,*

*siku leluang, kepala lalat, tulang ikan*) and abstract (*pucuk jala, kelarai putus masa, kelarai cik kedah, kelarai mak mek, kelarai sambas*).

In this research, the concept of transformation and tessellation on pandan mat weaving art at Kolej PERMATA Insan was analysed. The main objective is to determine the pattern of Kelarai Kepala Gajah between the combined transformation  $Z$ , followed by  $Y$ ,  $X$  and  $W$  that also can be written as transformation  $WXYZ$  and single transformation with enlargement. Besides, the pattern was verified whether the concept of tessellation has been applied on it.

## 2 METHODOLOGY

In this research, the pattern of Kelarai can be produced by using both method of combined transformation and single transformation. The uniqueness of this pattern can be seen when the final image under combined transformation and single transformation with enlargement remains the same. The procedure of combined transformation and single transformation were discussed in Subtopic 2.1 and 2.2.

### 2.1 Combined Transformation

Combined transformation is defined as applying more than one transformation concept on a geometric shape. Rotation, reflection, translation and enlargement are types of transformation concepts to make some changes in any given geometric shape.

A rotation is a transformation in which the object is rotated about the center of the rotation, while the direction can be clockwise or anticlockwise. A reflection is a transformation that occurs when all the points on the plane are reversed in the same plane on a line. The properties of the image under a reflection should be similar and congruent as the object. The image has different orientations, inverted sides, and forms mirror images with one another. Translation is a transformation in which all the points on the given plane are moved along a straight line in the same direction. Every point of the object is moved in the same distance. The shape, size and orientation remain the same. Enlargement is a transformation which has the center of enlargement that moves all points at a constant ratio known as scale factor from the center [15].

Combined transformation  $WXYZ$  means that transformation starts at  $Z$  followed by  $Y$ ,  $X$  and  $W$ . The pattern of Kelarai Kepala Gajah under the combined transformation  $WXYZ$  was determined where;

$W$ : Enlargement with scale factor 2 at center  $(7, -7)$

$X$ : Translation  $\begin{pmatrix} 7 \\ -7 \end{pmatrix}$

$Y$ : Reflection on line  $x = 0$

$Z$ : Rotation of  $180^\circ$  anticlockwise about the center origin

## 2.2 Single Transformation

Single transformation contains only one step of transformation in a geometric shape. The pattern of Kelarai Kepala Gajah under the single transformation of enlargement was compared to the final image of Kelarai Kepala Gajah under combined transformations  $WXYZ$ .

## 2.3 Tessellation

Tessellation is a pattern of recurring shapes that fill a plane without leaving empty or overlapping spaces [15]. Verification of tessellation concept in Kelarai Kepala Gajah pattern can be generalized to higher dimensions and various geometries that cover a surface, using one or more geometric shapes with no overlaps and no gaps.

## 3 RESULTS AND DISCUSSION

The process to get pattern of Kelarai Kepala Gajah will be discussed in Section 3.1.

### 3.1 Transformation

Figure 1 shows the process of object  $A$  (a cut of Kelarai Kepala Gajah pattern) undergoes combined transformation  $WXYZ$ . Figure 1(a) is the first step of combined transformation which is transformation  $Z$  that is a rotation of  $180^\circ$  anticlockwise about the center origin. Then, the Kelarai Kepala Gajah pattern was reflected on line  $x = 0$ . The image in Figure 1(b) showed the object  $A$  under the transformation  $Y$ . Next, object  $A$  undergoes transformation  $X$  and the image formed showed in Figure 1(c) while transformation  $X$  is a translation  $\begin{pmatrix} 7 \\ -7 \end{pmatrix}$ . Lastly, the object was enlarged with scale factor 2 at center  $(7, -7)$  in transformation  $W$ . Figure 1(d) showed the last image of Kelarai Kepala Gajah pattern under combined transformation  $WXYZ$ .

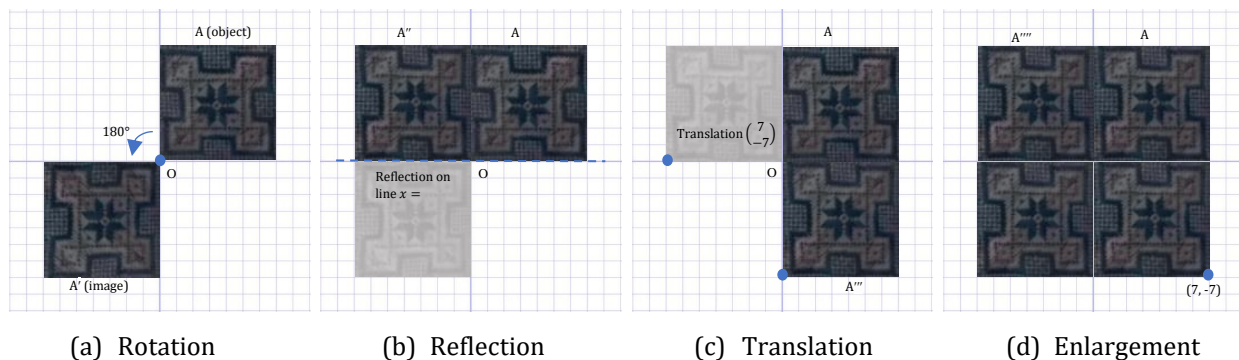


Figure 1 : Image of object  $A$  underwent combined transformation  $WXYZ$

Figure 2 shows the image of object  $A$  under single transformation. The enlargement with scale factor 2 at center  $(7, 7)$  in a single transformation shows the same results as the final image under combined transformation  $WXYZ$ . The uniqueness of Kelarai Kepala Gajah pattern can be shown when the final image remains the same for both combined and single transformation were applied.

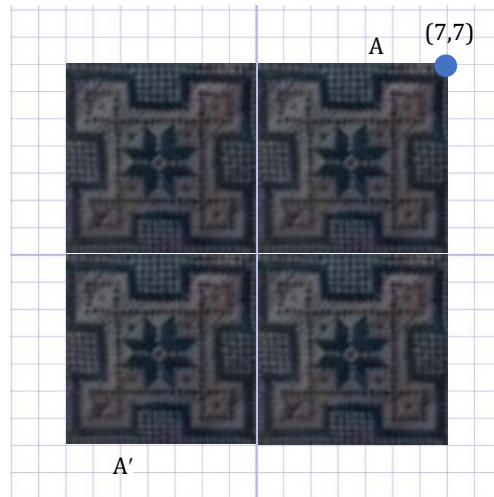


Figure 2 : Image of object  $A$  under single transformation with enlargement

Detail explanation about tessellation will be discussed in Section 3.2.

### 3.2 Tessellation

Figure 3 shows the image of tessellation concept on Kelarai Kepala Gajah pattern in the pandan mat weaving art at Reka Melayu Gallery, Kolej PERMATA Insan, where the concept of tessellation was applied in this pattern. The pattern and motifs in this mat are rich with mathematical values which can be seen on any geometric designs. Ethnomathematics can be shown when the two aspects of culture and mathematics were combined through the design.

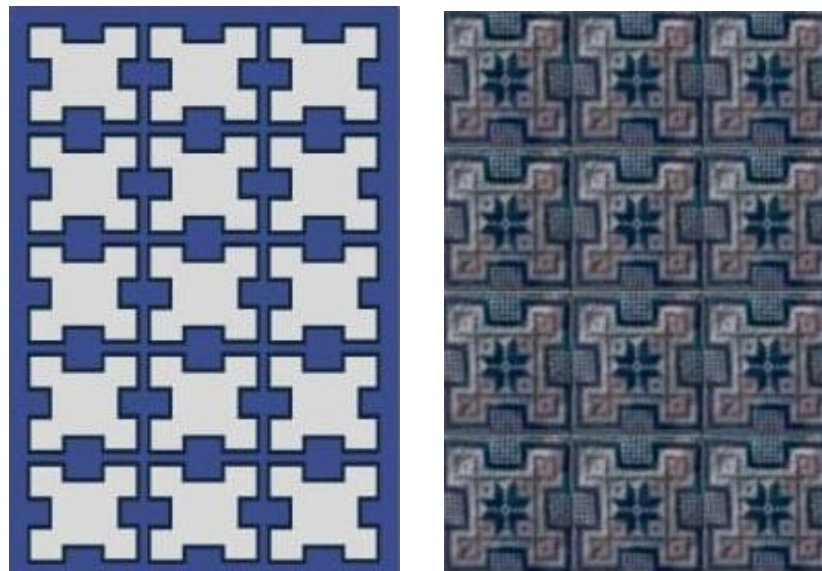


Figure 3 : Image of tessellation concept on Kelarai Kepala Gajah pattern in the pandan mat weaving art were displayed at Reka Melayu Gallery, Kolej PERMATA Insan

The uniqueness of the Kelarai Kepala Gajah in mat weaving can be seen from the balance between the woven patterns. In Islam, the balance makes the patterns more beautiful as the verse in Section 3.3.

### **3.3 Integration of Naqli and Aqli**

Stated in the Holy Quran, from Surah Al-Baqarah verse 143, which means:

*“Thus, We have made of you an Ummah justly balanced, that ye might be witnesses over the nations, and the Messenger a witness over yourselves...”*

The balanced community mentioned in the verse refer to us being the witnesses over the nation's act. Allah has put us in balance so that no one will be left behind and together helping each other. So, the balance is a very great thing. Islam teaches us to be moderate and balanced in all aspect of life whether it is about religion, daily activities, ideas and more. There is no such thing as overweight or else.

Balance is actually making us feel calm. In aspect of a design pattern, it is very true that if the pattern is not equally balanced, we will find it boring and not attractive. That's why the ancient people created this pandan mat design pattern repeatedly and constantly same. The balance in the pattern arouses our interest through the eye.

#### 4 CONCLUSION

Ethnomathematics is defined as mathematics that is built along with a society's value system, culture and outlook on life. This means that mathematics value is supported by the science of mathematics itself and the culture of society where mathematics is taught and developed. Mathematics includes an art that includes forms geometry that is processed and varied to produce an interesting pattern and perfect pattern. The application of mathematical skills has long existed among activist's art, so many geometric shapes are used as a reference for producing beautiful and symmetrical combinations of motifs and patterns. The geometric design of Malay nature usually applied in the art of weaving.

In this research, the concept of transformation and tessellation on pandan mat weaving art at Kolej PERMATA Insan was analysed. In mathematics, rotation, reflection, translation and enlargement are types of transformation concept to make some changes in any given geometric shape. The main objective is to determine the pattern of Kelarai Kepala Gajah between the combined transformation  $WXYZ$ , compared to the final image of Kelarai Kepala Gajah under single transformation and to verify whether the concept of tessellation has been applied in the pattern. Under the combined transformation,  $Z$  is defined as an anticlockwise rotation of  $180^\circ$  about the center origin. After rotation, the image formed was reflected using  $Y$  and  $X$  transformation, which are reflection on line  $x = 0$  and translation  $\begin{pmatrix} 7 \\ -7 \end{pmatrix}$  respectively. The transformation  $W$  described the final image of Kelarai Kepala Gajah pattern, where the concept of enlargement with scale factor 2 at center of  $(7, -7)$  was applied. At some point, the enlargement with scale factor 2 at center  $(7, 7)$  in a single transformation shows the same results as the final image under combined transformation  $WXYZ$ . The uniqueness of this pattern can be shown when the final image remains the same for both combined and single transformation were applied.

This pandan mat was made from sea pandan leaves (*Pandanus tectorius*), that is native to Malaysia, Eastern Australia, and the pacific islands. It can be found in the coastal lowlands typically near the edge of the ocean. The special features of this sea pandan leaf are it has high quality, can lasts longer between 20 to 40 years, stronger and more durable compared to another leaf like mengkuang. The weaving pandan mat displayed at Kolej PERMATA Insan shows the concept of transformation, single transformation, and tessellation for the entire woven pattern, which is Kelarai Kepala Gajah. Furthermore, this pandan leaf is more suitable and has more benefits, compared to other leaves.

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