

A Comparative Study of Geometrical Patterns: Escher's Tessalation and Passura Toraya Ornaments

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Abstract

This research aims to compare the geometric patterns in Passura Toraya and Escher's Tessalation. The study examines Toraja ornaments created 5.000 years ago from a geometric perspective that is similar to the approach of well-known geometric artist, M. Escher. The research method used is a descriptive qualitative method by collecting data from literature studies and visual observations of Passura Toraya, which are then analyzed using geometrical pattern and basic mathematic shapes. The results of the study show that (1) triangle, square, pentagon, flora, and fauna shapes represent geometric forms with similar tessellation techniques in both Passura Toraya and M.C. Escher's geometric patterns; (2) Passura Toraya has repeated patterns in opposite directions and four sides, as well as 4-fold designs, similar to M.C. Escher's tessellated geometric patterns with the same size as the empty field and 3-fold repetition levels; (3) contrasting colors are characteristic of Passura Toraya, similar to M.C. Escher's designs. Passura Toraya, which was made approximately thousands of years ago, shows the same approach as geometric artist, M. Escher. This demonstrates that Passura Toraya was made with a high level of knowledge, despite being made approximately 5.000 years ago.

Keywords: Geometry; Passura Toraya; Escher; Tessalation; Toraja.

1. Introduction

Passuraya Toraya is a geometric pattern that encompasses over a hundred intricate artistic creations by the Toraja people. Initially, Passura Toraya consisted of only four ornaments, but over time, the motif evolved, expanding to more than a hundred variations. Unfortunately, many of the symbolic meanings associated with these patterns have been lost. This loss is attributed to the Toraja people's oral tradition, which relied on storytelling rather than written records to preserve their cultural heritage. Consequently, it is essential to analyze the ornaments through their geometric patterns. Currently, there is a lack of formal research focused on examining Toraja motifs from a geometric perspective (Salam et al., 2022; Salam & Husain, 2017). This is particularly regrettable, as Passura Toraya carvings and motifs exhibit a remarkable array of geometric designs that reflect the Torajan people's sophisticated knowledge. Comparing these motifs to Escher's tessellation techniques could provide valuable insights into the advanced nature of Passura Toraya.

Previous research on Passura Toraya has explored its significance, highlighting its cultural and artistic importance. Studies could range from interpretations of meaning (Mukadas et al., 2024; Salam et al., 2022; Salam & Husain, 2017; Wijayanti, 2011) to technical aspects like geometric or mathematical patterns in the motifs (Fatharani & Rosandini, 2021; Triandika, 2021; Wibowo & Rosandini, 2023). The geometric patterns in Toraja motifs are crucial, as the knowledge embedded within them can be applied across various fields, such as business products, advertising, commercial design, and more (An & Jang, 2023; Huang et al., 2020; Rehman et al., 2022).

In addition, research on geometric patterns in decorative art has been widely applied in previous studies. One of the most famous graphic art masters for tessellation pattern implementation is M.C. Escher (İldeş, 2014; Kallosh & Linde, 2015; Mandal, 2022; Rodríguez-Sánchez et al., 2020; Schattschneider, 2010). Escher applied geometry with

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tessellation techniques, combining one or more geometric elements seamlessly, which has served as a reference for many researchers and designers in developing geometric designs (Ahmed, 2020; Huang et al., 2020).

Moreover, studies on the use of tessellation in different cultures are reflected in several works. Various cultural implementations of tessellation or rotation techniques inspired by Escher's geometric style have been used to develop both cultural and Islamic art (Abdullahi & Embi, 2013; Bozhko, 2019; Mohamed & Bande, 2022; Purniati et al., 2021). Therefore, this research serves as a strategy to develop and introduce Toraja decorative motifs from the geometric decorative perspective, which adds value beyond symbolic meaning.

Based on these issues, this study aims to introduce Toraja decorative motifs from a geometric pattern perspective by implementing tessellation techniques similar to those used by the geometry master M.C. Escher. Toraja motifs have profound symbolic meanings, yet they might have another crucial meanings. Passura Toraya also encompasses mathematical knowledge, visibly expressed in several geometric-patterned motifs. These geometric patterns demonstrate a mathematical structure a technique that has been implemented in several other Indonesian cultures, such as in Madura and East Nusa Tenggara (NTT) (Triandika, 2021).



Figure 1. Toraja Ornament on the Toraja Ornaments on the Walls of Toraja Tongkonan Houses

This research reveals that several Toraja ornaments feature geometric patterns using tessellation techniques. Geometric pattern analysis using tessellation techniques has not been explored in Toraja motifs before, as most studies focus on symbolic meanings. Hence, this study highlights the geometric tessellation technique inspired by M.C. Escher. If explored and applied, geometric tessellation patterns offer extensive benefits across various areas of life, not only in design and business but also with a great impact in the educational field.

In education, geometric tessellation patterns can enhance creativity, critical thinking, and scientific reasoning (Suratno, 2018). Teaching geometry and tessellation can be incorporated into designing learning activities in schools (Gómez-Chacon & Moralejo, 2022). Furthermore, applying geometric shapes in teaching, using tessellation techniques inspired by M.C. Escher, can increase student motivation (Hsu, 2020; Makawi, 2022, 2023).

2. Research Method

The research method used in this study is a qualitative descriptive approach, as it focuses on examining technical aspects. Data collection techniques include literature review and visual observation. The data collection process in this research is outlined in the following stages:

- a. Literature Review Method: This involves reviewing literature such as theses and journal articles with themes covering Passura Toraya, tessellation geometric patterns inspired by M.C. Escher, and the application of geometry in Indonesian and Islamic cultures, as well as its broader benefits, including in education.
- b. Visual Observation Method: This involves visually analyzing Toraja decorative motifs. The visual analysis employs geometrical pattern, and basic shapes in mathematics.

3. Results and Discussions

The research results show the use of geometric patterns with tessellation techniques in both Toraja decorative motifs and M.C. Escher's tessellation geometry. A comparative analysis was conducted by visually examining Toraja motifs and M.C. Escher's designs, particularly comparing the Toraja motif *Pa' Kapu' Baka* and Escher's Snakes Illustration design. The findings reveal the same use of tessellation techniques in these patterns.

This similarity is a significant aspect of this research. The findings highlight details in pattern use, geometric design, and contrasting colors, serving as strong indicators of tessellation geometry's application in Toraja motifs.

3.1. Toraja Decorative Pattern



Figure 2. Decorative Pattern of *Pa' Takku Pare* (Wijayanti, 2011)

In Salam et al. (Salam & Husain, 2017), the representational meaning of this decorative motif symbolizes drooping rice, conveying the values of humility and respect towards Dewi Sri.



Figure 3. Decorative patter of *Pa' Bulittong Siteba'* (Wijayanti, 2011)

In Salam et al. (Salam & Husain, 2017), the representational meaning of this decorative motif is swimming tadpoles, symbolizing hopes for peaceful and prosperous descendants. The colors used in this motif—black, yellow, and white



are important contrasting colors in the tessellation aspect and carry deep symbolic meanings.

Figure 4. Decorative patter of *Pa' Batang Lau* (Wijayanti, 2011)

In Wijayanti's (Wijayanti, 2011) thesis, the representational meaning of this decorative motif is stems and gourds, symbolizing family bonds that should be maintained regardless of distance, as they stem from a common ancestry.



Figure 5. Decorative patter of *Pa' Kapu' Baka* (Erlangga, 2024)

In Wijayanti's (Wijayanti, 2011) thesis, the representational meaning of this decorative motif is a basket. The motif resembles the intertwined form of a basket, symbolizing the hope that descendants remain united within the community and live in harmony, like items stored together within a basket.

3.1. Geometry of Tessalation Technique in M.C. Escher's Design



Figure 6. “Untitled” Design by M.C. Escher (Source: <https://mcescher.com/gallery/>)

In this untitled design, M.C. Escher created a seahorse pattern that showcases a flawless implementation of tessellation. The image features seahorses in three colors—red, blue, and white.

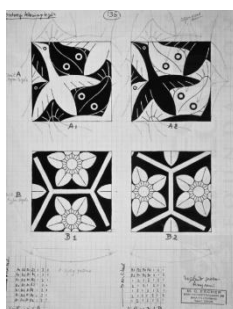


Figure 7. Sketch by M.C. Escher (Source: <https://mcescher.com/gallery/>)

The above design sketch shows the initial drawing before M.C. Escher applied tessellation, along with numbers underneath. This indicates that, in his design process, Escher first used mathematical calculations before creating the sketch.



Figure 8. “Untitled” Design by M.C. Escher (Source: <https://mcescher.com/gallery/>)

The design above displays a tessellation pattern composed of three colors: green, red, and white. The image also shows a clear sketch that reveals the drawing process involved in creating the design.



Figure 9. Snakes illustration by M.C. Escher (Source : <https://mcescher.com/gallery/>)

In the image above, there are three snakes arranged to form a triangle, with their heads, bodies, and tails creating the triangular shape. Although the triangle is not explicitly sketched in the image, the arrangement of the snakes, through their bodies and tails, is based on a pattern of large, medium, and small triangles, balanced with mathematical numbers.


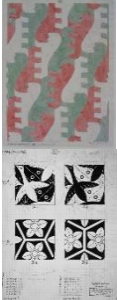

3.2. Visual Analysis of Toraja Decorative Motifs and M.C. Escher’s Design Images

Table 3.1. visual analysis of Toraja decorative motifs

Title of Decorative Motifs	Pa’ Takku Pare, Pa’ Bulittong Siteba’, Pa’ Batang Lau, and Pa’ Kapu’ Baka.	
Shape	Square, circle, and forms inspired by flora and fauna.	
Geometric Pattern	Repeating patterns with opposite directions, four-sided shapes in the second image, and 4-fold (four layers) pattern.	
Color	Contrasting colors; Black, Red, Yellow, and White.	
Composition Elements	Rice, Tadpoles, and Basket.	



Table 3.2. visual analysis of M.C. Escher's design images.

Title of Decorative Motifs	Untitled, Sketch by M.C. Escher, and Snakes.	
Shape	Triangles, pentagons, squares, and shapes of flora and fauna.	
Geometric Pattern	Tessellation geometric patterns with the same size as the empty space, as well as a 3-fold or three-level repeating pattern.	
Color	Contrasting colors: Red, Blue, Black, Green, Brown, White.	
Composition Elements	Seahorse, dog, bird, flower, and snake.	

Based on both analyses, it can be observed that the use of shapes, geometric patterns, and colors shows a high degree of similarity. The geometric shapes used generally include triangles, squares, pentagons, and others (Ahmed, 2020; Macgillavry, n.d.). At higher levels of geometry, the patterns move beyond simple polygons and begin to mimic natural forms, both flora and fauna. From both visual analyses, it is clear that the Toraja decorative motifs excel in terms of both aesthetics and technique. Furthermore, the geometric patterns in Toraja decorative motifs are highly dynamic and demonstrate design perfection, much like the works of M.C. Escher. Lastly, in terms of color, the maturity and depth of meaning are clearly evident in Toraja decorative motifs, whereas in M.C. Escher's designs, the artist uses color more freely and does not emphasize color as much (Macgillavry, n.d.).

3.3. Comparison of the Pa' Kapu' Baka Decorative Motif and M.C. Escher's Snakes Design.



Figure 10. Comparison of the Pa' Kapu' Baka Decorative Motif with M.C. Escher's Snakes Design

The image above may initially appear different and it may be difficult to identify the similarities. However, when geometric theory is applied to analyze the mathematical aspects, surprising similarities are revealed. This serves as evidence that the creation of Toraja decorative designs involves a deep and profound understanding of geometric principles.



Figure 11. Comparison of the Pa' Kapu' Baka Decorative Motif with M.C. Escher's Snakes Design in Terms of Pattern

The image above depicts layered patterns of 4-fold and 3-fold, or 4 levels and 3 levels. The image on the left shows a quadrilateral element with five levels of images, while the pattern's derivatives are shown on the right. The image on the right represents a 3-level pattern with four derivatives. The derivatives refer to the mathematical sizing of the images, where each level represents a different size of the same design, aiming to achieve harmony within the overall image design.

3.4. Discussion

This research examines the geometric aspects of tessellation techniques in Toraja decorative motifs. Based on the interpretation of Toraja motifs and the tessellation designs of M.C. Escher, both types of designs share similarities in their design methods. The use of geometric elements and high-level tessellation can be seen in both Toraja motifs and M.C. Escher's works.

Previous research has focused on the meaning of Toraja decorative motifs (Salam & Husain, 2017; Wijayanti, 2011), as well as the purpose of carving Toraja wooden motifs (Salam et al., 2022). However, no research has yet examined the technical aspects based on geometric patterns with tessellation techniques. This study identifies three interesting similarities in tessellation geometry patterns: shape, geometric pattern, and color.

First, in the visual analysis of Toraja motifs, repeating shapes in opposite directions and four-sided shapes in the second image were found, along with a 4-fold pattern. In M.C. Escher's design analysis, four samples revealed shapes such as triangles, pentagons, squares, and forms inspired by flora and fauna. This indicates that Toraja motifs exhibit a dynamic pattern in the direction of their creation, which aligns with M.C. Escher's designs. This finding supports previous research emphasizing the importance of geometric composition and dimensional structure in design thinking (Ahmed, 2020; Husain et al., 2022; Menni et al., 2018; Toribio, 2020).

Second, in the geometric pattern analysis of Toraja motifs, repeating shapes in opposite directions and four-sided shapes, along with the 4-fold pattern, were identified. Similarly, in M.C. Escher's designs, tessellation patterns with the same size as the empty spaces, and repetition in a 3-fold or three-tiered manner were observed. This supports earlier research on mathematically based geometric patterns (Schattschneider, 2010).

Third, contrasting colors are clearly visible in Toraja motifs, with colors such as black, red, yellow, and white. These colors are commonly seen in Toraja motifs and carry deep philosophical meanings. In M.C. Escher's designs, contrasting colors such as red, blue, black, green, brown, and white are present. In some works, black and white gradients play an important role. In line with previous research, contrasting color use in tessellation geometric designs is crucial (Bimler et al., 2004; Fatharani & Rosandini, 2021).

4. Conclusion

The Toraja decorative motifs titled *Pa' Takku Pare*, *Pa' Bulittong Siteba'*, *Pa' Batang Lau*, and *Pa' Kapu' Baka* share similarities with the tessellation geometry used by M.C. Escher. These similarities are found in the aspects of

geometric patterns, shapes, and contrasting colors. From this research, it can be concluded that Passura Toraya ornaments have similar approach to Escher's tessellation technique, which involve highly advanced mathematical patterns, an understanding of color theory. Thus, that is why only individuals with high level of creativity and profound knowledge of geometry and mathematics had created Passura Toraya. Therefore, it is paramount to conduct more research from geometrical and mathematical approach.

A suggestion from this research is that to appreciate the value of Toraja ornaments, the perspective on understanding them should be broader and not limited to one particular approach. This study focuses on the complex tessellation geometry technique. Therefore, the researcher hopes that studies related to tessellation geometry can be further developed, particularly in techniques that are still unfamiliar to many. Research related to tessellation and Toraja decorative motifs can still be expanded into design implementation. This opens up opportunities to further develop Toraja culture, from different perspective.

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