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GEOMETRIC PRACTIES IN CULTURAL CONTEXTS: AN ETHNOMATHEMATICAL ANALYSIS OF THE KEBUMEN WAYANG KAYON

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ABSTRACT

Matematika tidak hanya hadir sebagai sistem simbol formal, tetapi juga berkembang sebagai praktik berpikir yang terintegrasi dalam aktivitas budaya. Penelitian ini bertujuan menganalisis unsur-unsur matematika pada kayon wayang kulit Kebumen sebagai representasi praktik berpikir matematis, serta menelaah relevansinya dalam konteks pembelajaran geometri. Penelitian menggunakan pendekatan kualitatif interpretatif dalam kerangka etnomatematika dengan perspektif emic–etic. Data dikumpulkan melalui observasi visual, wawancara semi-terstruktur dengan dalang sekaligus pengrajin kayon, serta dokumentasi dan studi pustaka. Analisis data dilakukan secara tematik-interpretatif dengan menautkan praktik budaya dan konsep matematika formal. Hasil penelitian menunjukkan bahwa struktur segitiga, simetri cermin, pola pengulangan ornamen, dan proporsi tinggi–lebar pada kayon berfungsi sebagai mekanisme praktis untuk mencapai keseimbangan estetis dan fungsional, bukan sekadar bentuk visual. Temuan ini menegaskan bahwa pengetahuan matematis non-formal memiliki legitimasi epistemologis dalam konteks budaya. Penelitian ini berkontribusi pada penguatan kerangka teoretis etnomatematika dengan mereposisi artefak budaya sebagai praktik berpikir matematis, serta memberikan dasar konseptual bagi pengembangan pembelajaran geometri berbasis budaya.

Mathematics is not only manifested as a formal symbolic system but also develops as a form of thinking embedded in cultural practices. This study aims to analyze the mathematical elements of the kayon (gunungan) in Kebumen shadow puppetry as representations of mathematical practices and to examine their relevance for geometry education. A qualitative interpretative approach within the framework of ethnomathematics was employed using an emic–etic perspective. Data were collected through visual observation, semi-structured interviews with a puppeteer-craftsman, and documentation supported by relevant literature. The data were analyzed thematically and interpretatively by linking cultural practices with formal mathematical concepts. The findings reveal that the triangular structure, reflective symmetry, repetitive ornament patterns, and height–width proportions of the kayon function as practical mechanisms for achieving aesthetic balance and functional stability rather than merely as visual forms. These results demonstrate that non-formal mathematical knowledge possesses epistemological legitimacy within its cultural context. This study contributes to the theoretical development of ethnomathematics by repositioning cultural artifacts as representations of mathematical

practices and provides a conceptual foundation for culturally responsive geometry learning.

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1. INTRODUCTION

Mathematics is increasingly understood not only as a neutral and universal system of formal symbols, but as a practice of knowledge that grows, is used, and interpreted in certain socio-cultural contexts (Madusise, 2019). This perspective places mathematics as part of human activity that is intertwined with the values, goals, and needs of society (Toromade et al., 2024). Within this framework, ethnomathematics serves not only to identify the forms of mathematics in cultural artifacts, but also to interpret how cultural practices represent a lively and functional way of mathematical thinking in a given community (Suciyati Sartika et al., 2025).

In the latest literature, ethnomathematics is positioned as a field of study that highlights the legitimacy of non-formal mathematical knowledge, the relationship between mathematical practices and mathematical objects, as well as differences in emic and ethical perspectives in understanding meaningful activities mathematically (Likur et al., 2024). Thus, the focus of ethnomathematics does not stop at the recognition of geometric shapes or visual patterns, but rather on explaining why and how such mathematical structures emerge, are maintained, and used in certain cultural practices (Sains dan Teknologi et al., 2025). This approach expands the discourse of mathematics education by presenting mathematics as contextual, meaningful, and rooted in the collective experience of society (Rahmadani et al., 2022).

In the context of mathematics education, the ethnomathematical approach has important pedagogical implications (Villarin et al., 2024). The integration of cultural context in learning has the potential to bridge the gap between abstract school mathematics and students' real experiences (Siregar et al., 2024). Learning that departs from cultural practices allows students to understand mathematical concepts as the result of real problem solving, not just symbolic procedures (Irfan Habibi et al., 2025). Therefore, ethnomathematics is seen as relevant to efforts to develop meaningful, reflective, and conceptual understanding-oriented learning.

One of the cultural artifacts that is rich in visual structure, symbolic meaning, and social function is wayang kulit. In the Javanese puppet tradition, puppets not only play a role as a performance medium, but also as a representation of knowledge systems, cosmological values, and visual order that are inherited from generation to generation (Anggoro, 2018). Among the important elements in the puppet show is kayon (mountain), which serves as a marker of the scene transition as well as a symbol of life and the order of

the cosmos. Visually, kayon displays an arrangement of shapes, symmetry, patterns, and proportions that are not random, but rather tied to certain aesthetic and functional conventions (Dewi, 2023).

A number of previous ethnomathematical studies have examined mountains or other traditional art artifacts by highlighting the existence of flat buildings, symmetry, and patterns. However, most of these studies still focus on object descriptions and inventories of general mathematical concepts (Djannah et al., 2024). Studies that place cultural artifacts as representations of mathematical thinking practices—that is, how artisans or cultural actors intuitively use considerations of form, balance, and proportion—are still relatively limited (Ian Perasutiyo et al., 2022). In addition, studies that link ethnomathematical findings with conceptual implications for reflective geometry learning have also not been widely developed (Sari, 2025).

Wayang kulit Kebumen has different visual characteristics compared to wayang styles from other regions in Java, both in terms of ornament composition, simplicity of form, and emphasis on visual balance (Syahida et al., 2019). These characteristics reflect the social and aesthetic context of local communities, while also opening up opportunities to examine how standard forms, symmetry, and proportions are practiced as non-formal mathematical knowledge (Purnama et al., 2022). However, ethnomathematical studies that specifically place Kebumen puppet puppets as representations of mathematical practices and elaborate their meanings for mathematics education are still very limited.

Based on these gaps, this study aims to analyze the mathematical elements in the Kebumen puppet puppet not only as a visual object, but as a result of cultural practices that represent mathematical thinking. This research focuses on the interpretation of basic shapes, symmetry, repetition patterns, and proportions as mathematical practices that have aesthetic, symbolic, and functional functions (Purnama et al., 2022). In addition, this study discusses the relevance of these findings in enriching geometry learning through an ethnomathematical approach.

The novelty of this research lies in the effort to reposition the study of ethnomathematics from mere concept identification to interpretive analysis of mathematical practices in local cultural artifacts. Thus, this research is expected to contribute to strengthening the theoretical framework of ethnomathematics while providing a conceptual basis for the development of contextual and meaningful geometry learning, both at the national level and in the broader mathematics education discourse.

2. METHODS

2.1. Research Design

This study uses an interpretive qualitative approach in the framework of ethnomathematics. This approach was chosen because the purpose of the research is not just to identify mathematical forms in cultural artifacts, but to interpret the practice of mathematical thinking that is internalized in the process of making and interpreting Kebumen wayang kulit kayon. Ethnomathematics is positioned as an epistemological approach that examines the relationship between cultural practices (emic perspective)

and formal mathematical concepts (etic perspective), thus allowing for analysis that goes beyond mere visual descriptions.

2.2. Research Object and Context

The object of the research is Kebumen-style puppet puppet forest. The research will be carried out in November 2025 in Redisari Village, Rowokele District, Kebumen Regency, Central Java, which is one of the centers for craftsmen and practitioners of wayang kulit art. This context was chosen because the kayon used is still produced and interpreted in the tradition of active puppetry, so that it represents a living cultural practice, not just a museum artifact.

2.3. Data Source

The data sources in this study include visual data (physical forms of kayon and ornaments), verbal data (interviews with puppeteers-craftsmen), and documentary data (photographs, field notes, and relevant literature). The selection of informants was carried out purposively with consideration of the depth of experience and direct involvement in the cultural practices studied.

2.4. Data Collection Techniques

Data were collected through limited participatory observations, semi-structured interviews, and visual documentation. Observations are focused on the regularity of shape, visual balance, and proportion. The interviews were directed to explore aesthetic, symbolic, and functional considerations in the practice of kayon-making.

2.5. Data Analysis Techniques

The analysis was carried out thematically-interpretively through the stage of data reduction, thematic coding of mathematical practices, emic-ethical interpretation, and reflective conclusion drawn.

2.6. Data Validity and Ethics

The validity of the data is maintained through triangulation of techniques, perseverance of observation, and reflective dialogue with the literature. The research pays attention to the ethics of qualitative research with informant consent and identity disguise.

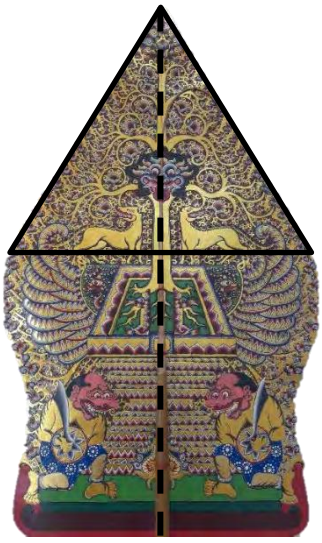
3. HASIL DAN PEMBAHASAN

3.1. Hasil

The results of observation indicate that the Kebumen *kayon* is consistently constructed with a main structure resembling an isosceles triangle. This overall form serves as the visual and functional foundation of the *kayon*, as illustrated in **Figure 1**. The triangular structure does not merely represent a geometric shape but reflects a practice of

visual balance that has become a standard in *kayon* production. Interviews reveal that craftsmen do not rely on formal mathematical terminology; instead, they refer to the principle of being "upright and balanced" to ensure that the *kayon* is easy to manipulate and remains stable when inserted during performance. As shown in **Figure 2**, the triangular form combined with a vertical axis supports visual symmetry and functional stability. From a mathematical perspective, this structure can be interpreted as balanced mass distribution and vertical symmetry.

Figure 1: Overall structure of the Kebumen *kayon*



Firuge 2: Triangular structure and vertical mirror symmetry

The ornaments on the surface of the *kayon* are composed of simple shapes such as circles, trapezoids, and rectangles, as presented in **Figure 3**. From the craftsmen's perspective, the placement of ornaments is intended to fill space so that the surface appears orderly and visually complete. Analytically, this arrangement reflects a practice of spatial organization and two-dimensional field division. The ornaments are arranged hierarchically from the base to the top of the *kayon*, indicating deliberate regulation of scale and position rather than random placement. This hierarchical structure reinforces visual coherence while maintaining the dominance of the main form.

Figure 3: Spasial organization and hierarchical ornament arrangement

Visual analysis further reveals a strong mirror symmetry along the vertical axis of the *kayon*, which can be clearly observed in **Figure 2**. This symmetry is maintained consistently because it is perceived as a symbol of balance and beauty within the cultural tradition. In practice, symmetry is regarded as an essential condition for the *kayon* to appear harmonious and visually "alive." From a mathematical standpoint, this reflects an intuitive application of geometric reflection and congruence without reliance on formal procedures or symbolic calculations.

Along the edges of the *kayon*, repeated leaf and flame ornaments form a clear visual rhythm, as shown in **Figure 4**. This repetition is not determined through numerical calculation but emerges through experience and habitual craftsmanship. The presence of repeated motifs indicates that mathematical regularity can arise from intuitive, practice-based processes. These patterns demonstrate an implicit understanding of repetition, consistency, and visual sequencing embedded in traditional craftsmanship.

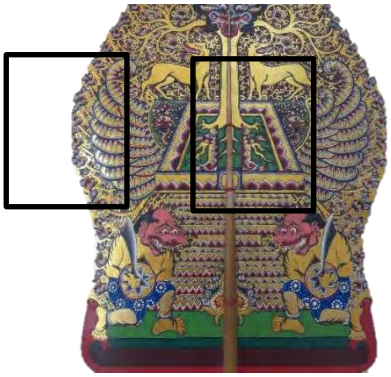


Figure 4: Repetitive ornament patterns forming visual rhythm

Observations and interviews also show that the construction of the *kayon* follows a specific height-to-width ratio that is considered ideal by craftsmen. This proportional relationship, illustrated in **Figure 5**, maintains the dominance of the main triangular structure while providing sufficient space for ornamentation. From a mathematical perspective, this practice relates to the concepts of ratio and proportion, whereas culturally it functions as a traditional convention transmitted across generations through apprenticeship and practice.

Figure 5: Height-width proportion of the *kayon*

Overall, these findings demonstrate that the shape, symmetry, patterns, and proportions of the Kebumen *kayon* constitute manifestations of mathematical thinking practices embedded in cultural activity. Rather than appearing as abstract formal constructs, mathematical ideas operate as practical, aesthetic, and culturally meaningful practices within the tradition of shadow puppetry.

3.2. Discussion

The findings of this study show that the mathematical elements in the Kebumen puppet cannot be reduced to the appearance of geometric shapes alone. The identified triangle structure, symmetry, pattern, and proportions serve as a practical mechanism for achieving visual and functional balance in puppet performances. This confirms that mathematics in the cultural context operates as a mathematical practice, not just as a formal object (Purnama et al., 2022). This perspective is in line with contemporary ethnomathematics which views cultural activity as the locus of the production of contextual and meaningful mathematical knowledge (Kusuma et al., 2024).

The main structure of the kayon that resembles an isosceles triangle represents an adaptation to the needs of visual stability and regularity (Dewi, 2023). The form is not generated through formal mathematical procedures, but rather through empirical experience internalized in the practice of making kayon. These findings suggest that mathematical knowledge can develop through visual intuition and cultural conventions, thus challenging the dichotomy between formal and non-formal mathematics that has dominated mathematics education discourse (Prahmana & D'Ambrosio, 2020).

The consistent mirror symmetry in the kayon shows a close relationship between aesthetics, symbolism, and mathematics (Dewi, 2023). In cultural practice, symmetry is interpreted as a representation of harmony and balance, while in mathematical frameworks it represents geometric transformations (Purnama et al., 2022). The legitimacy of symmetry in this context does not depend on symbolic proof, but on function, social acceptance, and the continuity of tradition. Thus, these findings reinforce the view that non-formal mathematical knowledge has epistemological validity in its own cultural context.

The pattern of repetition of ornaments and the height–width proportions of the kayon suggest that mathematical order can arise from practical rationality. Craftsmen maintain visual consistency through experience and work habits, not through explicit numerical calculations (Ian Perasutiyo et al., 2022). Nonetheless, the practice results in regularity that is in harmony with the concepts of patterns and comparisons in formal mathematics. This confirms that mathematical rationality is not always manifested in the form of symbols and formulas, but also in stable and predictable spatial decisions.

Different from ethnomathematical studies that stop at the inventory of geometric concepts, this study repositions kayon as a representation of mathematical thinking practices (Surya Wijaya, 2025). The emic–etic approach allows for an analysis that not only answers *what* mathematical concepts are present, but also *how* and *why* they function in cultural practice (Djannah et al., 2024). Thus, the contribution of this research lies in strengthening the theoretical framework of ethnomathematics by placing cultural artifacts as an epistemological source for understanding mathematics as a human activity.

From the perspective of mathematics education, these findings provide a conceptual basis for the development of culture-based geometry learning (Nuraini et al., 2023). Kebumen puppet puppets can be used as a learning context that emphasizes the meaning, function, and reason for the emergence of mathematical concepts in real practice. However, the pedagogical implications proposed are conceptual and have not been empirically tested, so further research is needed to examine their implementation in the classroom context (Susilowati, 2021).

Overall, this discussion confirms that Kebumen's puppet show how mathematics is present and works as a contextual social practice. The findings of this study contribute to the ethnomathematical discourse by expanding the understanding of the legitimacy and function of mathematical knowledge in cultural practice.

4. CONCLUSION

This study shows that Kebumen puppet puppets represent the practice of mathematical thinking that is integrated in cultural activities, not just visual artifacts that contain geometric shapes. The triangular structure, symmetry, repetition pattern, and proportions in kayon serve as practical mechanisms to achieve aesthetic and functional balance in puppet performances. These findings confirm that mathematical concepts can develop and operate meaningfully through cultural practices without relying on formal symbolic formulations.

The main contribution of this research lies in the repositioning of ethnomathematical studies from the mere identification of mathematical objects to the analysis of

mathematical practices that function in cultural contexts. Using an emic-ethical approach, this study shows how non-formal mathematical knowledge has legitimate and relevant epistemological legitimacy in the puppet tradition. Thus, cultural artifacts are understood not only as a learning context, but also as a source of knowledge to understand the nature of mathematics as a human activity.

From the perspective of mathematics education, the findings of this study provide a conceptual basis for the development of culture-based geometry learning that emphasizes the meaning, function, and practical rationality behind mathematical concepts. However, the pedagogical implications put forward are conceptual and have not been empirically tested. Therefore, further research needs to examine the implementation and impact of kayon-based learning in the classroom context, as well as conduct comparative studies on other cultural artifacts to expand the contribution of ethnomathematics in mathematics education.

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