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Geometric patterns of the Papua crown: A culturally inclusive approach to mathematics learning

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Abstract

Embracing inclusivity and integrating cultural artifacts into mathematics teaching and learning has sparked the attention of many researchers for decades. Despite these conceptual advancements, the design and implementation of inclusive mathematics instruction in Papua, Indonesia, remains limited. Mathematics teaching and learning in Papua are still primarily dominated using government-provided textbooks. Addressing this void, this article discusses the use of Papua Crown as an inclusive mathematics learning medium due to its relevance to learners' daily lives. We highlight the exotic and rich patterns of the Papua Crown, which can be utilized to teach elementary school mathematics, particularly geometry. We employed an ethnographic approach by conducting observations with the artisans and users of the Papua Crown, interviews with two artisans, a museum curator, an archaeologist, and an anthropology lecturer, and documentation. We analyzed the connection between the geometric patterns in the Papua crown and the geometric concept that the teacher can potentially utilize in their practice. The findings elucidate that there are three geometric patterns in the Papua Crown: the triangle, symbolizing the human spiritual relationship with nature and God; the square, representing beliefs and ways of life based on nature; and the circle, personifying the life cycle of Papuan society. We hypothesize that Papua Crown can provide meaningful and engaging mathematics teaching and learning, as learners can identify existing patterns in geometry, particularly 2D shapes. Third, using geometry patterns from the Papua Crown in teaching and learning mathematics is predicted to assist learners in learning mathematical concepts contextually and appreciate culture by constructing knowledge from their experiences. This study is expected to contribute significantly to the development of a culturally inclusive mathematics learning that enables learners to understand mathematics concepts and honor the pluralism of Indonesian society.

Keywords: Culturally Inclusive Mathematics Learning, Ethnography, Ethnomathematics, Geometric Patterns, Papua Crown

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Inclusivity has become a central concern across multiple disciplines in recent decades, though its precise meaning varies depending on cultural, social, and educational contexts (Ainscow et al., 2006; Artiles et al., 2006). Within education, inclusivity is often defined as the provision of equitable opportunities that support the diversity of learners, including those with special needs (Amstrong et al., 2010). In mathematics education, Gervasoni and Peter-Koop (2020) emphasized that inclusion should not be confined to students with disabilities but must also encompass learners with diverse abilities and rights to access mathematics. The implementation of inclusive mathematics education seeks to enable all learners, without exception, to participate actively in mathematical activity (Bertram & Rolka, 2022; Höveler, 2019; Magnate, 2025; Scherer & Bertram, 2024). Achieving this vision requires teachers to carefully attend to learners' strengths, needs, and learning environments (Fitzgerald et al., 2021). One instructional strategy that supports inclusivity is the use of learning materials drawn from learners' everyday experiences, which can facilitate accessibility and render mathematics more meaningful (Nurfadhillah et al., 2021).

Despite these conceptual advances, the design and enactment of inclusive mathematics instruction in Indonesia remains limited. In particular, mathematics teaching in Papua continues to rely heavily on government-provided textbooks (Sianturi & Hurit, 2024; Tanujaya et al., 2021). Teachers seldom develop instructional materials that align with students' characteristics or cultural contexts. Yet mathematics is not a culture-free discipline; it is shaped by cultural, social, geographical, environmental, and historical influences (D'Ambrosio, 2016; Risdiyanti & Prahmana, 2018; Utami et al., 2020). To address this issue, D'Ambrosio (1985) introduced the concept of ethnomathematics, an approach that integrates mathematical ideas, methods, and techniques derived from community practices. Ethnomathematics situates mathematics in cultural contexts, thereby enabling students to develop not only conceptual understanding but also critical, democratic, and tolerant dispositions (D'Ambrosio, 2016; Rosa & Orey, 2016). This approach has been shown to enhance students' motivation, interest, and creativity in learning mathematics.

Papua, and particularly Jayapura, is home to diverse communities whose cultural practices remain deeply embedded in daily life. For instance, carvings on cultural objects such as crowns feature triangular, square, and circular motifs symbolizing mountains, stilt houses, and the sun—representations of knowledge systems and sources of wisdom within society. Haryanto et al. (2015) further documented geometric patterns in Noken, a traditional Papuan artifact. UNESCO's designation of Noken as Intangible Cultural Heritage in 2012 (Marjanto et al., 2017) affirms the epistemic value of such cultural products as reservoirs of knowledge. These examples demonstrate that cultural practices embedded in everyday life can provide powerful resources for fostering inclusive mathematics learning.

A considerable body of research has examined inclusive mathematics learning media that incorporate cultural dimensions, typically highlighting three key characteristics (Buchori et al., 2023; Liang & Sedig, 2010; Mairing et al., 2024; Mania & Alam, 2021; Prahmana & D'Ambrosio, 2020). Firstly, the use of learning media can make mathematics instruction more effective by reducing its inherent abstractness and rendering concepts more concrete and accessible to learners (Mania & Alam, 2021). Such media also increase students' interest and motivation, thereby enhancing understanding. For example, Liang and Sedig (2010) demonstrated that interactive media supports children's comprehension of mathematical ideas, while Buchori et al. (2023) showed that interactive resources improve teachers' instructional effectiveness, particularly in mathematics classrooms. Field observations further suggest that students engage more actively and express greater enthusiasm when mathematics lessons are mediated through visually engaging and interactive tools. Thus, interactive and well-designed learning media not only support teachers in delivering lessons but also contribute to reshaping students' perceptions of mathematics in a positive direction.

Secondly, cultural artifacts provide valuable resources for contextualizing mathematics instruction. Motifs found in traditional textiles or carvings often contain embedded mathematical patterns that can serve as entry points to formal concepts. Integrating such artifacts into instruction situates mathematics within local wisdom, thereby enhancing learners' engagement and rendering mathematics more meaningful. For instance, Prahmana and D'Ambrosio (2020) conducted an ethnographic study of Yogyakarta batik, demonstrating that its unique motifs reflect geometric transformations as well as local philosophical, moral, and historical values—such as leadership and ethical conduct—that can be explored alongside mathematical content. Similarly, Mairing et al. (2024) documented mathematical structures in the motifs of the Dayak Ngaju people in Central Kalimantan, illustrating how geometry can be taught in ways that are culturally relevant and value laden. Collectively, these studies affirm that local cultural knowledge and artifacts can enrich mathematics instruction by fostering connections between abstract concepts and learners lived experiences. However, most such studies have been conducted in central or western Indonesia (e.g., Javanese batik and Dayak Ngaju motifs), leaving a significant gap in research on culturally grounded mathematics instruction in Papua, where indigenous knowledge systems remain underrepresented in formal schooling.

Finally, the use of materials derived from daily life supports learners in making meaningful connections between mathematics and their immediate experiences. Familiar objects encountered in everyday contexts can function as bridges between abstract concepts and real-world applications, thereby enhancing both relevance and motivation. Mania and Alam (2021) showed that incorporating ethnomathematics into the Indonesian national curriculum allows students to both understand mathematical content and affirm their cultural identity. Nicol and Crespo (2005) demonstrated that engaging students with Mayan numeration systems within their historical and social contexts sparked curiosity and supported cross-cultural mathematical exploration. More recently, Danoebroto et al. (2024) found that teachers' integration of ethnomathematics into lesson design fostered diverse modes of mathematical thinking, while Hunter and Hunter (2024) emphasized that embedding cultural practices in instruction enables learners to engage meaningfully in the construction of mathematical understanding. Taken together, these findings underscore the potential of local culture and everyday practices to serve as powerful resources for cultivating mathematical thinking.

For decades, mathematics instruction in Papua has been mediated through contexts that bear little relevance to local culture. The national curriculum and textbooks, including both their content and language, remain largely disconnected from the lived experiences and cultural backgrounds of Papuan students (Sianturi & Hurit, 2024). Teachers have not developed study units that adequately respond to the characteristics and needs of Papuan learners. To address this gap, the present study introduces the Papua Crown, a culturally significant artifact that features geometric motifs—including triangles, squares, and circles—that encode social, spiritual, and environmental knowledge. Although prior research has examined the mathematical significance of other Papuan cultural products, such as the knots of Rumah Kaki Seribu (Haryanto et al., 2016) and the architecture of Honai houses (Kho et al., 2025), no study to date has systematically analyzed the potential of the Papua Crown's geometric patterns as a medium for geometry learning in formal educational settings. This study therefore responds to calls for culturally inclusive approaches to mathematics teaching in elementary schools and contributes to the growing literature on inclusive learning.

The study is guided by two research questions:

1. What geometric patterns are embodied in the Papua Crown, and what cultural meanings do these patterns represent within Papuan society?
2. How can the geometric patterns in the Papua Crown be utilized to support culturally inclusive mathematics learning in elementary school classrooms?

Accordingly, the article aims to provide a detailed account of how the Papua Crown, as a cultural artifact, can be employed as an alternative medium for teaching geometry that is both mathematically rigorous and culturally enriching. We argue that the Papua Crown offers a promising basis for inclusive learning for three reasons. First, its geometric motifs embody both mathematical structures and local cultural values. Second, learners are more likely to understand mathematical concepts when these are represented through familiar, culturally situated patterns. Third, the uniqueness of the Papua Crown reflects a strong sense of cultural identity, encouraging learners to appreciate and preserve their heritage while engaging with mathematics.

METHODS

This study employed an ethnographic approach (Merriam & Tisdell, 2016) to describe, analyze, and interpret the cultural practices of Papuan communities, focusing specifically on the ethnomathematical concepts embedded in the Papua Crown. Ethnography was chosen because it enables the natural examination of the relationships between culture and mathematics, as exemplified by the geometric patterns found in the crown. This approach also facilitated an understanding of the cultural significance of these patterns through direct engagement with community members and artisans. Accordingly, the study emphasizes how geometric motifs, transmitted across generations, can be contextualized in mathematics education to strengthen connections between mathematical knowledge and local wisdom.

Data Collection

Data were collected through observations, interviews, and documentation. Observations involved directly examining the design and structure of the Papua Crown to identify its geometric features. Semi-structured interviews were conducted with two crown artisans (one male, one female), a cultural expert serving as a museum curator, an archaeologist, and an anthropology lecturer. These interviews focused on the processes of crafting the crown, the meanings attributed to its motifs, and its potential applications in mathematics instruction. Documentation of written references and visual records further supported the analysis.

Validity and Trustworthiness

To ensure validity, the study employed source triangulation (Denzin & Lincoln, 2018). The same questions were posed to different informants, allowing for cross-verification of responses. Data from interviews were compared with observations and documentary evidence to minimize bias and enhance credibility. This triangulated approach provides a robust foundation for interpreting the Papua Crown as a culturally grounded unit of study in mathematics education.

Data Analysis

Data analysis followed the framework of Miles, Huberman, and Saldaña (2014), consisting of three stages:

1. Data reduction – selecting and refining information from observations, interviews, and documentation, with particular attention to identifying geometric patterns, underlying mathematical principles, and their relation to the crown’s design.
2. Data display – organizing findings into narrative descriptions, tables, and images to illustrate geometric motifs and their potential relevance for mathematics learning. At this stage, triangulation was again applied to corroborate interpretations across data sources.

3. Conclusion drawing – synthesizing results to elucidate how the crown's geometric patterns can be incorporated into mathematics education in ways that are both culturally meaningful and mathematically rigorous.

Through this analytic process, we associated the identified geometric concepts with Papuan cultural knowledge and emphasized the role of the Papua Crown as a pedagogical medium. Embedding cultural elements in mathematics instruction is conjectured to support students in learning mathematical concepts not only in abstract form but also in ways that foster cultural appreciation and identity.

RESULTS AND DISCUSSION

The Papuan Crown: A Cultural Artifact and Its Construction

Papua, characterized by its remarkable ethnic diversity encompassing approximately 250 distinct tribes, represents a unique locus of cultural expression and identity (Indrawan et al., 2019; Rumansara, 2015). Among the most prominent manifestations of this cultural heritage are ornamental headpieces. For example, in the Dani tribe, men traditionally wear headbands crafted from natural materials. A headband made from bird feathers is referred to as swesi, whereas one produced from cuscus hair is called siloki inon (Merina & Muhaimin, 2023).

These cultural artifacts, while rooted in tradition, have undergone transformations over time. The influences of market demand and contemporary aesthetics have fostered innovation, resulting in more flexible designs that integrate novel elements while preserving cultural authenticity. Collectively, these modified headpieces are now widely recognized as the "Papua Crown."

Figure 1. Variations of the Papua Crown

As illustrated in Figure 1, the Papua Crown embodies both structural ingenuity and aesthetic richness, achieved through the careful integration of traditional materials. The primary components of its construction are derived directly from the natural environment. First, khombow bark serves as the foundational base of the crown. Second, red saga seeds are incorporated as decorative elements, symbolizing courage. Third, bia shells, originating from mollusks, introduce a maritime dimension, signifying the intrinsic relationship between Papuan communities and the sea. Finally, feathers from cassowaries and goats are affixed to the crown, imbuing it with distinctive elegance and visual complexity.

The significance of material selection is underscored by a local craftswoman, depicted in Figure 2, who emphasized the non-arbitrary, intentional process underlying crown production. As she explained:

> *"The Papuan crown is made entirely of natural materials. It contains khombow bark, red saga seeds, bia shells, cassowary feathers, cenderawasih feathers, and goat hair. We collect these materials from the forest, carefully process them, and transform them into a beautiful crown." (I. Theresia, personal communication, May 19, 2024).*

This testimony highlights the intrinsic relationship between artistry, ecology, and cultural identity. The integration of natural resources not only enhances the symbolic meaning embedded in the Papua Crown but also reinforces its aesthetic and spiritual value.

Figure 2. A local craftswoman in Papua

Contemporary Production and Educational Significance of the Papua Crown

At present, the Papua Crown is widely produced by local artisans who integrate traditional wisdom with modern influences, as illustrated in Figure 3. These artisans emerge from communities that preserve ancestral knowledge and customary practices, while simultaneously adapting to the demands of tourist and collector markets. The process of crown-making involves meticulous attention to symmetry, proportion, and precision, resulting in a visually harmonious artifact. Each component holds symbolic meaning, often signifying the wearer's social status, authority, and identity.

This significance was emphasized by a cultural expert from the Museum Loka Budaya of Cenderawasih University, who explained:

> *"The materials used often have meaning. They indicate a person's position, social class, and role in society. Papuan crowns are usually made by highly skilled craftsmen who pass down their knowledge and skills through tradition. The process is rigorous: careful measurements are taken, and natural, locally sourced materials are used. This fosters a strong connection between the community and the environment." (E. Y. Kondologit, personal communication, April 27, 2024).*

This testimony reinforces two central points: first, that the Papua Crown functions as a social marker embedded in material culture; and second, that its production requires a mathematical sensibility of measurement, proportion, and spatial reasoning, inherited through generations of artisanal practice.

Figure 3. Modern Papua Crown

The Papua Crown is typically worn by leaders, customary authorities, and community representatives during ceremonies to symbolize honor, legitimacy, and cultural continuity. Informants consistently highlighted that the crown embodies not only aesthetic appeal but also profound social and spiritual significance. An anthropology lecturer at Cenderawasih University elaborated:

> *"A crown is usually worn during important moments, such as weddings, religious rituals, or cultural celebrations, which emphasize the position and role of the wearer within the community. As a cultural artifact that reflects the identity of the tribe and the wisdom of the locals, the use of the Papua Crown at present extends beyond ethnic and religious boundaries." (A. Krey, personal communication, April 20, 2024).*

According to this perspective, the Papua Crown now extends beyond traditional contexts and is increasingly featured in formal events, cultural festivals, national parades, and carnivals. This expanded use illustrates the adaptability of Papuan culture, reinforcing unity in diversity while maintaining symbolic integrity.

Beyond its cultural and symbolic dimensions, the construction of the Papua Crown demonstrates inherent mathematical properties that offer rich opportunities for educational integration. The crown's design exhibits geometric regularity, with elements arranged according to principles of symmetry, proportionality, and balance. Repeated shapes and aligned patterns create a rhythmic visual structure, reflecting mathematical notions of tessellation, congruence, and transformation.

These characteristics provide a meaningful context for teaching and learning mathematics. For instance, the repetitive placement of feathers illustrates rotational symmetry, while the circular arrangement of seeds and shells embodies radial geometry. Observing and analyzing these patterns allows students to connect mathematical abstractions—such as measurement, proportion, and spatial reasoning—to tangible cultural artifacts.

Thus, the Papua Crown serves not only as a cultural symbol but also as a pedagogical resource. Through contextual exploration, students can observe how geometry and measurement are embedded in daily life, fostering the integration of mathematics with local culture, meaning-making, and identity. This approach aligns with ethnomathematical perspectives, wherein mathematical concepts are situated within cultural practices, thereby enhancing relevance and engagement in mathematics education.

Geometric Symbolism in the Papua Crown

The Papua Crown incorporates a variety of geometric patterns, among which triangular motifs are particularly significant. These patterns illustrate the cultural richness of Papua while simultaneously providing opportunities for mathematical interpretation. By observing such motifs, learners can connect abstract concepts of geometry—such as angles, sides, and proportional relationships—to concrete cultural representations, thereby deepening understanding and retention.

One prominent triangular pattern appears in the arrangement of cassowary feathers that decorate sections of the crown (Figure 4). This arrangement not only enhances the artifact's visual authenticity but also symbolizes the intimate relationship between Papuan culture and the surrounding natural environment, a relationship that is vital to sustaining community life. The triangle, in this context, holds profound spiritual meaning. As one cultural expert explained:

> *"The triangle has profound symbolic meaning. It represents the spiritual connection between humans and God. Each point on the triangle has a different meaning—the first represents the living human, the second represents the spirit world, and the third represents heaven, humanity's ultimate destination. Thus, we understand this triangle as representing the three stages of human life." (E. Y. Kondologit, personal communication, April 27, 2024).*

The triangular peak, as depicted in Figure 4, resembles a mountain summit and symbolizes the ultimate goal of the human spiritual journey—an element central to Papuan cosmology. Mountains are traditionally regarded as sacred, embodying proximity to both God and the ancestors. Furthermore, the triangular composition conveys balance, an essential principle in Papuan culture. The symmetrical arrangement of feathers creates harmony among humans, nature, and the spiritual world.

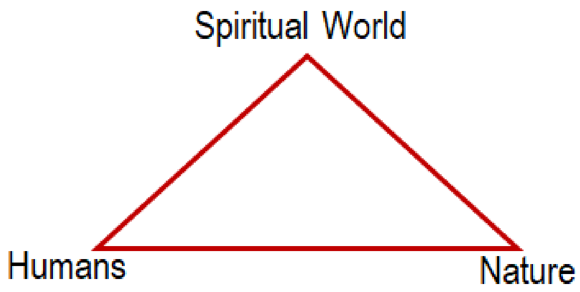

Figure 4. Harmonious triangle pattern illustration

Thus, triangular patterns in the Papua Crown serve multiple roles: they signify authority and social status, embody spiritual aspirations, and reinforce the value of balance in life. From an educational perspective, these motifs exemplify how geometry is embedded in cultural artifacts. By studying such patterns, students can recognize geometric properties such as vertex structure, symmetry, and proportionality, while also engaging with the symbolic meanings that shape local identity.

The Papua Crown is not only a cultural symbol but also a manifestation of what may be termed "natural mathematics" embedded in tradition. Geometric motifs—such as triangular and quadrilateral forms—illustrate how Papuan society has incorporated mathematical structures into artistic expression and daily life. These motifs reveal how concepts such as symmetry, proportion, and balance are practiced in material culture, demonstrating that beauty and meaning often emerge from simple geometric forms. For educational purposes, such patterns offer an ideal medium for contextualizing abstract mathematical ideas, enabling students to connect geometry with real artifacts and cultural knowledge.

Quadrilateral motifs appear in several ornamental elements of the Papua Crown (Figures 5 and 6). First, the khombow bark, which serves as the primary structural material, exhibits natural rectangular textures. These patterns are associated with symbolic meanings of balance and harmony with nature. Second, the arrangement of red saga seeds forms linear rectangular bands across the crown. As explained by a cultural expert:

> *“The red saga seeds symbolize strength and life due to their striking color. They enhance the crown's beauty and reflect the close connection between Papuan culture and nature, giving it profound symbolic meaning.” (E. Y. Kondologit, personal communication, April 27, 2024).*

These components, while enhancing aesthetic appeal, also communicate cultural values and the interdependence of humans and the natural environment.

Figure 5. Quadrilateral patterns created by the arrangement of red *saga* seeds

Similarly, bia shells—mollusks collected from Papua’s coastal areas—are arranged in rectangular sequences, symbolizing the wealth of the sea, a resource central to local livelihoods. As another informant emphasized:

> *“The Bia, a type of shell found in the coastal waters of Papua, symbolizes the abundance of the sea, an important natural resource for the local community. Not only is the crown beautiful and decorative, but it also reminds us of the close relationship between humans and the sea.” (E. Y. Kondologit, personal communication, April 27, 2024).*

Thus, the quadrilateral motifs of the Papua Crown not only serve decorative functions but also embody ecological wisdom, reminding younger generations of their responsibility to preserve natural resources. Quadrilateral forms also hold broader significance in Papuan material culture.

Figure 6. Quadrilateral patterns created by the arrangement of *bia* shells

Rectangular shapes are prevalent in both coastal and inland communities, where they appear in structural elements of traditional houses, as confirmed by an archaeologist:

> *“In both coastal and inland communities in Papua, rectangular shapes are commonly found in everyday objects, including pieces of wood used to build traditional houses.” (E. N. I. Djami, personal communication, May 7, 2024).*

These patterns extend further to functional objects such as stone axes and knives, where rectangular and square shapes are adopted for their practicality and durability. A local craftsman noted that these tools embody both utility and a deep relationship with nature. Symbolically, the square conveys stability, foundation, and social order within Papuan society.

The routine integration of quadrilateral forms into tools, architecture, and ceremonial artifacts underscores the inseparability of nature, culture, and mathematics. In this sense, the Papua Crown exemplifies how geometric reasoning is embedded in cultural artifacts. For learners, quadrilateral motifs provide opportunities to investigate concepts such as right angles, parallel lines, and proportionality within a meaningful cultural context, thereby enriching both mathematical understanding and cultural appreciation.

Every cultural artifact embodies the values of the community that produces it. The Papua Crown exemplifies this principle, with its frequent use of quadrilateral and circular motifs. While quadrilateral forms convey stability and order, circular patterns enrich the crown's symbolic and mathematical significance, extending its meaning far beyond decoration.

Circular motifs, located in the central section of the crown (Figure 7), hold multiple layers of symbolic meaning. As one cultural expert explained:

> *"The local community forms a hook-shaped circle with three main meanings. First, the turtle shell inspires the circle, symbolizing the human life cycle, starting from birth, continuing through childhood, adolescence, adulthood, and finally death. Thus, this cycle continues, keeping the rotor turning. Second, the circle represents the water cycle of Lake Sentani, including the ebb and flow of water. Third, the water cycle is likened to an eye, symbolizing that 'ancestors are currently watching you,' meaning that your ancestors observe every action you take." (E. Y. Kondologit, personal communication, April 27, 2024).*

This explanation illustrates how the circle encapsulates Papuan cosmology: it symbolizes cycles of life, continuity in nature, and the ongoing presence of ancestral spirits.

In addition to these cosmological associations, circular forms are inspired by natural elements central to Papuan life. The rising sun above the mountains symbolizes energy, warmth, and the interdependence of humans with natural cycles. Similarly, circular designs resemble the eyes of animals and motifs found on turtle shells. Within Papuan belief, turtles embody endurance, strength, and longevity, further reinforcing the circle as a symbol of vitality and respect for nature.

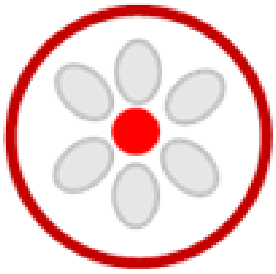

Figure 7. Circular pattern representation in the Papua Crown

Philosophically, the circle is widely regarded as a universal symbol of unity and continuity, a perspective also evident in Papuan culture. The unbroken line of the circle conveys infinity and interconnectedness, reflecting the belief that human life is inseparable from nature and the spiritual world.

From a mathematical standpoint, the circle represents fundamental concepts such as rotational symmetry, periodicity, and infinite continuity. These geometric principles are reflected in the cultural symbolism of cycles—of life, water, the sun, and ancestral presence. For educational purposes, the circular patterns of the Papua Crown offer students a culturally grounded entry point into geometry. By analyzing these motifs, learners can explore properties of circles, symmetry, and cycles, while simultaneously engaging with the cultural meanings attached to them.

Thus, the circular motifs of the Papua Crown exemplify how mathematical forms are embedded in cultural artifacts, demonstrating the intersection of geometry, identity, and spirituality. They not only enrich Papuan traditions but also serve as powerful pedagogical tools for contextualizing mathematics in meaningful cultural practice.

Pedagogical Implications

Various pattern geometries on the Papua crown can help learners understand geometry concepts such as the circumference, area, and diameter of a circle. During this process, many children tend to memorize formulas to complete questions without truly understanding their meaning, which can lead to difficulty and a subsequent loss of the formula. By utilizing the motifs on the Papua Crown, teachers can potentially teach geometry in a fun and engaging way that children easily understand. The result is that the children not only know the formula but also gain a deep understanding of the concept. The pattern on the Papua Crown consists of various shapes and sizes, which allows teachers to teach circumference, area, and combinations of numbers. Additionally, children can study comparisons, such as comparing circumference and area. Approach this by deepening the learners' understanding of scale and comparison, as well as helping the learner estimate the quantities of materials needed for a balanced aesthetic, one that is good in size and proportion and features geometric patterns, such as the Papua Crown.

Learning can begin by inviting children to identify patterns, symmetry, and transformation in the crown motif. The child can make a sketch or draw patterns found on the exercise sheet. Next, they can create a replica Papua Crown using naturally available ingredients around them. This activity supports the *Merdeka* curriculum (independent curriculum) principles, which emphasize learning through a contextual and culturally based approach, providing learners with experiences that foster creative and contextual learning.

Table 1. Hypothetical mathematics teaching and learning activities based on the use of the Papua Crown

Phase	Indonesian Elementary School Geometry Learning Objectives	Teacher Activities	Learners Activities	Aspect: Inclusiveness, Interactive, Collaborative
A (Grade1-2)	Learners are able to recognize 2D and 3D shapes, arrange and decompose 2D shapes, and determine the	● Introduce pattern triangles, squares, and circles with pictures and real objects, then assign	● Learners identify pattern triangles, squares, and circles on the Papua Crown, and then create a pattern model of 2D shapes that are	**Inclusivity:** ● Accommodating all learners' learning styles.

Phase	Indonesian Elementary School Geometry Learning Objectives	Teacher Activities	Learners Activities	Aspect: Inclusiveness, Interactive, Collaborative
	position of object among other objects.	learners to create a pattern model of triangles, squares, and circles as many as there are on the crown of Papua using an ice cream stick. • Explain the draft position of relatively shaped objects : triangles, squares, and circles.	embodied on the Papua Crown using an ice cream stick. • Learners are formed in pairs. A learner is on duty, composing, and others explain the position of the object.	**Interactive:** • Learners interact in a direct way. **Collaborative:** • Learners can work in the same group.
B (Grade 3-4)	• Learners are able to describe characteristic features of various forms of 2D shapes, compose and decompose various 2D shapes in multiple possible ways.	• Explain characteristic features of triangles, squares, and circles in a general way. • Assign a task: make a replica model of a Papua Crown containing elements, triangles, squares, and circles.	• Learners identify and characterize properties of 2D shapes on the Papua crown. • Learners create a replica of the Papua Crown, which contains triangle, square, and circle shapes, then present it.	**Inclusivity** • Supporting learners with visual impairments. • Accommodating all learners' learning styles. **Interactive** • Learners interact in a direct way. **Collaborative** • Learners collaborate in a group.

Phase	Indonesian Elementary School Geometry Learning Objectives	Teacher Activities	Learners Activities	Aspect: Inclusiveness, Interactive, Collaborative
C (Grade5-6)	● Learners can construct and decompose 3D shapes (cube, cuboid, and their combinations) and recognize spatial visualization (perspective from front, top, side), compare characteristics among 2D shapes and among 3D shapes, and determine locations on maps that use a grid system.	● Explain concepts and characteristics as well as guide making pattern triangles, squares, and circles using the Papua Crown.	● Observe and identify characteristic features of 2D shapes (triangle, square, and circle). ● Make patterns of 2D shapes with various sizes and analyze the possibility of what would happen if the crown of Papua had different sizes of 2D shapes.	**Inclusivity:** ● Contrasting colors help learners with a visual learning style. ● The teacher's verbal explanations assist learners with auditory learning. **Interactive:** ● Learners interact directly with the Papua Crown. **Collaborative** ● Learners can collaborate in groups.

The hypothetical mathematics learning activities presented in Table 1 provide opportunities for learners to engage in meaningful mathematical experiences, enabling them to understand abstract concepts through culturally relevant contexts. By integrating the Papua Crown as a learning medium, these activities situate mathematical ideas within tangible cultural artifacts, thereby bridging the gap between abstract reasoning and concrete experience.

In Phase A, learners are introduced to the recognition and classification of two-dimensional shapes—specifically triangles, squares, and circles—based on their properties and characteristics. Learners then model these shapes as they appear in the Papua Crown (e.g., triangular feather arrangements, quadrilateral bark patterns, and circular shell ornaments). This phase aligns with Bruner's cognitive learning theory (Angraini et al., 2023; Wen, 2018), which progresses through the enactive stage (action-based exploration), the iconic stage (image-based representation), and the symbolic stage (abstraction). Following this sequence allows learners to ground their understanding of shapes in familiar cultural artifacts before advancing toward abstract conceptualization (Dwijayanti et al., 2017).

In Phase B, learners engage in multimodal learning activities. The first step involves observing and identifying geometric shapes in the Papua Crown, an approach that supports visual learners by emphasizing imagery, patterns, and color. Sheromova et al. (2020) emphasized that visual learners grasp mathematical material more effectively when presented through direct observation of objects and vivid representations. In the second step, learners present their observations orally, thereby fostering communication and collaboration skills. This stage particularly benefits auditory learners, who process knowledge most effectively through listening and speaking. In the third step, learners construct replicas of the Papua Crown using locally available materials. This activity requires tactile engagement and experimentation, catering to kinesthetic learners who learn best through physical interaction (Bosman & Schulze, 2018).

In Phase C, learners undertake more advanced tasks that require critical and analytical thinking. Specifically, they compare and integrate different two-dimensional shapes to design an aesthetically balanced crown. At this stage, learners—typically aged 11 years and above—are capable of engaging in abstract reasoning without relying exclusively on physical objects (Laja & Hijriani, 2022). They can formulate hypotheses, evaluate possible outcomes, and apply deductive reasoning to solve problems. This process develops higher-order thinking skills, moving learners beyond basic recognition toward synthesis and evaluation.

Overall, the conjectured learning activity (Table 1) demonstrates how the Papua Crown can function as a culturally responsive medium for mathematics education. Because mathematical concepts are inherently abstract, learners often struggle when instruction is detached from concrete experiences. Scholars have argued that effective primary school mathematics instruction requires culturally and contextually relevant media to scaffold abstract reasoning (Tay et al., 2024; Toh et al., 2017). Furthermore, the activities outlined here foster the development of critical, logical, and creative thinking skills—competencies essential not only for solving mathematical problems but also for addressing broader challenges in everyday life (Tanudjaya & Doorman, 2020). Rather than relying on rote memorization of formulas, learners are encouraged to actively construct knowledge, engage in problem-solving, and make meaningful connections between mathematics and their cultural environment.

Hypothetical mathematics learning activities, as illustrated in Table 1, suggest that the Papua Crown can serve as a powerful medium for fostering meaningful learning experiences. Because the crown is frequently showcased in cultural and educational contexts, learners are likely to feel a stronger connection to mathematical content when it is taught through this artifact. Sianturi and Hurit (2024) noted that embedding mathematics in cultural contexts not only enriches students' learning but also nurtures positive attitudes toward the subject. When mathematics instruction is situated in learners' cultural realities, students tend to be more motivated, active, and willing to engage with increasingly complex mathematical concepts (Kurniawan et al., 2024).

The use of the Papua Crown also provides an opportunity to enhance cultural awareness and appreciation of diversity within Indonesia. As Deby and Yahfizham (2023) and Rodríguez-Nieto et al. (2025) argued, culturally responsive pedagogy transforms mathematics from being perceived as abstract and rigid into a discipline that reflects the dynamic interplay between knowledge and lived experience. Thus, learning mathematics through the Papua Crown not only supports cognitive development but also promotes tolerance, inclusivity, and an appreciation for cultural identity. The crown, therefore, transcends its aesthetic value, becoming a medium rich in educational significance and effective in connecting mathematical knowledge with cultural heritage.

Collaborative learning through the Papua Crown, as structured in Phases A, B, and C, also cultivates social competencies. Learners are encouraged to collaborate, share perspectives, and engage in discussions, thereby improving communication and interpersonal skills. These experiences enable students to value diverse perspectives while developing habits of cooperation—an essential dimension of 21st-century education.

We hypothesize that the Papua Crown embodies geometric principles that are simultaneously aesthetic and culturally significant. Its design and construction reflect mathematical reasoning in practice, making it a compelling resource for exploratory learning. Manipulative media such as the crown allow learners to interact with tangible representations of abstract concepts, which facilitates conceptual understanding (Muhaimin & Juandi, 2023). Previous studies also support this claim: Prahmana and D'Ambrosio (2020) found that integrating local culture into mathematics instruction enriches learners' comprehension of geometry, while other researchers have emphasized the motivational and cognitive benefits of culturally embedded mathematics activities (Garcia-Olp et al., 2019; Hunter & Miller, 2022).

Learning mathematics through the Papua Crown can also stimulate creativity. For example, when learners are tasked with designing or replicating crowns, they engage in problem-solving and imaginative reasoning. Such activity-based learning promotes both conceptual and procedural fluency (Maphutha et al., 2023; Nwoke, 2021). Moreover, group-based tasks foster teamwork and communication skills that are essential for problem-solving in contemporary contexts (Toh et al., 2017). Thus, integrating Papuan cultural artifacts into mathematics instruction strengthens not only mathematical competencies but also transversal skills.

Importantly, incorporating the Papua Crown can foster inclusivity. Native Papuan children may experience affirmation of their cultural identity when their traditions are acknowledged in the classroom, while children from other ethnic groups can develop appreciation and respect for cultural diversity (Hunter, 2022; Sianturi et al., 2022). Such an approach aligns with research demonstrating that culturally responsive mathematics teaching enhances engagement, strengthens learners' sense of belonging, and deepens their appreciation of the discipline (Hunter & Miller, 2022).

Furthermore, culturally grounded instruction can help narrow performance gaps between learners in urban and remote areas. Educational access in Papua is often hindered by geographic and infrastructural challenges (Sianturi et al., 2022). By employing the Papua Crown as an accessible and familiar learning medium, mathematics instruction can become more equitable. The approach also lends itself to adaptation for learners with special needs. For example, tactile engagement with the crown's geometric motifs may support visually impaired learners, while collaborative tasks may be particularly beneficial for learners on the autism spectrum. Storytelling connected to the crown's cultural symbolism can further support children who struggle with abstract reasoning. Thus, the Papua Crown provides an avenue for teaching mathematics while simultaneously fostering inclusivity, diversity, and social values such as tolerance and respect.

This approach embodies culturally relevant pedagogy (Ladson-Billings, 1995), which emphasizes academic success, cultural competence, and critical consciousness. When learners encounter mathematics in ways that acknowledge their cultural backgrounds, they are more likely to develop confidence, see their heritage as meaningful, and experience a stronger sense of identity and belonging (Gay, 2015; Thomas et al., 2024). The Papua Crown thus symbolizes equity and inclusivity, situating mathematics learning within learners' lived realities.

Moreover, the Papua Crown accommodates diverse learning styles. For auditory learners, teachers can emphasize verbal explanations of mathematical properties such as perimeter. Visual learners benefit from observing and analyzing the crown's geometric motifs, while kinesthetic learners can create two-dimensional models or replicas to deepen their understanding. These practices confirm findings by Bosman and Schulze (2018) and Sheromova et al. (2020), who demonstrated that kinesthetic and multimodal learning strategies improve children's grasp of abstract concepts. By allowing flexible pedagogical approaches, the Papua Crown strengthens the effectiveness of mathematics instruction.

Despite these promises, this study remains exploratory and has several limitations. First, the analysis is restricted to the identification of geometric elements in conceptual terms and has not yet been tested in actual classroom settings. Second, curriculum integration has not been fully considered, and student learning outcomes remain unmeasured. Third, this study primarily focuses on modernized versions of the crown commonly used in public ceremonies, which may overlook the rich diversity of traditional Papuan crowns across different ethnic groups, many of which may embody more complex geometric structures. Future research should therefore investigate these variations and empirically evaluate the pedagogical potential of integrating Papuan cultural artifacts into mathematics education.

CONCLUSION

The Papua Crown, as a cultural artifact, incorporates diverse geometric patterns—primarily triangles, quadrilaterals, and circles—that embody symbolic meanings deeply rooted in Papuan traditions. These patterns, with their diversity of shapes and colors, provide visually rich and pedagogically valuable resources for mathematics education. For children, the crown offers a contextualized and meaningful way to recognize and understand geometric concepts. Its use as a learning medium supports inclusive mathematics education by accommodating different learning styles and abilities, including those of learners with special needs. Furthermore, learning mathematics through the Papua Crown fosters the development of higher-order thinking skills—creativity, critical reasoning, collaboration, and communication—while simultaneously strengthening cultural preservation and identity formation. In this sense, the Papua Crown functions not only as an aesthetic cultural symbol but also as a culturally grounded pedagogical tool that connects mathematics learning to national plurality.

However, the integration of the Papua Crown into mathematics instruction must be approached carefully. Not all mathematical elements embedded in the crown directly correspond to competencies outlined in the primary school curriculum. Thus, thoughtful pedagogical design is needed to ensure that cultural representations enrich rather than obscure the targeted mathematical concepts. Teachers must also exercise cultural sensitivity, as the Papua Crown embodies symbolic and spiritual meanings for Papuan communities. To avoid misinterpretation or cultural distortion, collaboration with artisans, cultural experts, and local elders is essential when employing the crown as a teaching medium.

Based on these considerations, we propose three recommendations. First, mathematics teachers should receive professional development and training focused on effective strategies for integrating the Papua Crown into geometry instruction. Second, curriculum developers should design and implement teaching modules centered on geometric patterns in the crown, ensuring consistent and equitable use in both urban and rural schools. Third, further empirical research is required to investigate the cognitive, affective, and social impacts of integrating the Papua Crown into mathematics instruction, particularly its effects on students' conceptual understanding, motivation, and cultural identity. By embedding mathematics learning within the context of the Papua Crown, educators can foster inclusive and culturally relevant pedagogy that enhances mathematical understanding while simultaneously affirming cultural diversity and identity.

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