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Exploring Honai construction as a resource for mathematics learning

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Abstract

Cultural heritage plays a critical role in providing context for mathematical learning, offering opportunities to enhance both academic understanding and cultural appreciation. However, there is a gap in integrating ethnomathematical knowledge into formal education, particularly in connecting local cultural practices with abstract mathematical concepts. This study addresses this gap by examining the ethnomathematics of the Dani community, focusing on the construction of the Honai, a traditional structure that reflects the community's indigenous knowledge and craftsmanship. The research aims to identify and analyze the mathematical concepts embedded in the Honai's construction, thereby demonstrating how these principles can inform culturally responsive mathematics education. Using a qualitative ethnographic methodology, data were collected through participant observation, in-depth interviews with traditional builders and community elders, and document analysis. The findings reveal that the Honai incorporates various mathematical principles, including circular geometry in its base, conical or paraboloid shapes in its roof, and non-standard measurement techniques based on body spans and visual alignment. These results highlight the rich geometric, proportional, and spatial reasoning inherent in the Honai's design and construction. The study demonstrates that incorporating the Honai's construction principles into mathematics instruction can enhance student engagement and deepen conceptual understanding by linking abstract concepts to culturally significant practices. This culturally responsive approach not only bridges traditional knowledge with academic content but also fosters pride in cultural identity. By leveraging cultural artifacts like the Honai, this research contributes to the development of inclusive and effective educational strategies that enrich mathematics teaching and learning.

Keywords: Dani Tribe, Ethnomathematics, Geometry, Honai, Qualitative Ethnographic

Introduction

The integration of cultural heritage into educational curricula has garnered increasing attention as a means to enhance students' learning experiences and safeguard Indigenous knowledge (Brottman et al., 2020; Stahl & Maznevski, 2021). This approach not only strengthens the connection between students and their cultural identities but also promotes an inclusive and contextually relevant framework for education. By embedding traditional knowledge within curricula, educators can effectively bridge the gap between Indigenous wisdom and contemporary academic concepts, thereby enriching educational outcomes while preserving cultural heritage. Ethnomathematics, a discipline that investigates the interplay between mathematics and culture, as well as the ways in which mathematical concepts emerge, develop, and are applied in specific cultural contexts, offers valuable perspectives on the cultural dimensions of mathematical understanding (Prahmana & D'Ambrosio, 2020). Integrating traditional cultural artifacts into mathematics education enhances the relevance and engagement of learning experiences (Machaba & Dhlamini, 2021; Mania & Alam, 2021). Moreover, this approach fosters a deeper appreciation for diverse cultural heritages while promoting critical thinking and problem-solving skills through the application of abstract mathematical concepts in culturally meaningful contexts.

Indonesia's rich cultural diversity offers unique opportunities for applying ethnomathematical approaches in education (Umbara et al., 2021). The Honai, a traditional house of the Dani people in Papua, exemplifies a cultural artifact with significant mathematical value due to its distinctive architectural design (Patasik, 2022). The construction of the Honai incorporates geometric concepts and spatial reasoning that align closely with mathematical topics taught in schools. However, the potential of the Honai as a medium for mathematics education remains underexplored (Sabon & Telussa, 2024). Integrating the architectural features of the Honai into mathematics instruction could deepen students' understanding of geometric principles while fostering an appreciation for the cultural significance of this traditional structure.

Previous studies have demonstrated the efficacy of using Indigenous knowledge and cultural practices to teach mathematical concepts (Noprisa et al., 2024; Rangkuti & Siregar, 2023). For instance, Noprisa et al. (2024) investigated the application of ethnomathematics in teaching geometry concepts using the traditional Kedatun Keagungan house, highlighting its potential for instruction in geometry and algebra. Similarly, Rangkuti and Siregar (2023) examined mathematical ideas embedded within diverse cultural practices, emphasizing both the universality and cultural specificity of mathematical thought. These findings suggest that integrating the Honai into mathematics education could enhance students' comprehension by contextualizing abstract concepts within their cultural framework. Such an approach not only makes mathematics more relatable and meaningful for students but also nurtures cultural pride and identity.

Culturally responsive teaching practices emphasize the importance of acknowledging and integrating students' cultural backgrounds to shape their learning experiences effectively (Abacioglu et al., 2020). Leveraging cultural artifacts such as the Honai enables educators to cultivate an inclusive classroom environment that validates and respects students' cultural identities (Abdulrahim & Orosco, 2020). Research has shown that this approach enhances academic performance, fosters a sense of belonging, and boosts students' self-esteem (Yunita & Sarajar, 2024). By incorporating cultural artifacts into teaching, educators bridge the gap between students' lived experiences and academic content, making learning more engaging and meaningful. This approach not only inspires students to value their heritage but also encourages active contributions to their communities and society.

Ethnomathematics enriches the mathematics curriculum by challenging the Eurocentric view of mathematics as an abstract, culture-free discipline (Machaba & Dhlamini, 2021). By acknowledging the mathematical contributions of various cultures, educators can present a more comprehensive and accurate account of the historical development of mathematical ideas (Moura & Rodrigues, 2024; Reinholz, 2022). This perspective helps students appreciate the global and cultural dimensions of mathematics, demonstrating its relevance to their own cultural contexts (Ascher, 2018). Recognizing the dynamic interplay between culture and mathematics enables students to understand how mathematical concepts are shaped and applied in diverse societies. This approach fosters critical thinking, broadens academic perspectives, and cultivates an appreciation for the cultural richness underpinning mathematical innovation.

The architectural features of the Honai provide valuable opportunities to explore a variety of mathematical concepts. Its circular base serves as a practical example for teaching concepts such as circles, circumference, area, and the properties of geometric shapes (Kho & Siep, 2022). The conical or paraboloid design of the roof introduces advanced topics in three-dimensional geometry, including surface area and volume (Kho & Siep, 2022). Furthermore, the construction process of the Honai involves essential mathematical skills such as measurement, estimation, and proportional reasoning, which are fundamental in mathematics education (Leung, 2020). Engaging students with real-world applications of mathematical principles not only makes abstract concepts more tangible but also enhances accessibility. This approach also allows students to recognize the practical utility of mathematics in traditional practices, fostering both cultural appreciation and a deeper understanding of the subject.

Incorporating the Honai into mathematics lessons aligns closely with the principles of Realistic Mathematics Education, which emphasizes teaching mathematics through real-world contexts and applications (Van den Heuvel-Panhuizen & Drijvers, 2020). This approach suggests that students achieve greater understanding and retention when mathematical concepts are connected to meaningful, relatable situations. Utilizing the Honai as a contextual framework enables educators to promote experiential learning while enhancing students' problem-solving abilities (Muhtadi et al., 2017).

Despite its benefits, implementing ethnomathematical approaches in education poses several challenges (Sunzuma & Maharaj, 2021). Educators may face limitations in resources or lack the knowledge required to effectively integrate cultural artifacts into their teaching practices (Wulandari et al., 2024). Additionally, rigid curriculum structures and the emphasis on standardized testing may hinder the adoption of innovative teaching methods (Nahar, 2023). Addressing these challenges necessitates targeted professional development and institutional support for teachers, as well as policy reforms that prioritize culturally responsive education (Mpuangnan & Ntombela, 2024). By bridging cultural heritage with mathematics, this approach not only deepens students' conceptual understanding but also instills a sense of pride and awareness in their cultural identities. Therefore, this study aims to investigate the ethnomathematics of the Dani community in the construction of the Honai, with a particular focus on uncovering the traditional knowledge and practices embedded in the process. Furthermore, it seeks to identify and analyze the mathematical concepts inherent in the construction, thereby creating a bridge between cultural heritage and mathematical understanding.

Methods

This study employed a qualitative research methodology with an ethnographic design to investigate the ethnomathematical concepts inherent in the construction of the Honai by the Dani community. The ethnographic approach was selected to facilitate an in-depth examination of cultural knowledge and practices within their authentic context, ensuring the reliability and contextual relevance of the findings.

Data collection was conducted using three primary methods: participant observation, in-depth interviews, and document analysis. During participant observation, the researchers actively engaged in the Honai construction process, closely observing the techniques, materials, and cultural practices involved. Detailed field notes and photographic documentation were systematically compiled to capture the sequential construction process and to elucidate the cultural meanings embedded in each structural element of the Honai. This method provided direct insights into the practical application of traditional knowledge and the implicit mathematical principles underpinning the process.

In-depth interviews were conducted with key informants, including traditional builders and community elders, to gain a comprehensive understanding of the cultural significance and mathematical knowledge involved in Honai construction. The interview protocol was designed to explore the historical and cultural context of the Honai, the mathematical principles applied, and the community's perspectives on the interplay between their traditional practices and mathematical concepts. All interviews were audio-recorded, transcribed verbatim, and subjected to thematic analysis to extract meaningful patterns and insights.

Document analysis was utilized to complement the primary data by examining existing literature, historical archives, and traditional manuscripts related to the Dani community and the construction of Honai. This method provided a broader contextual framework, enriching the understanding of the cultural and mathematical aspects associated with Honai.

Data analysis was carried out using a qualitative content analysis approach, focusing on identifying mathematical concepts embedded within the construction process. Particular attention was given to exploring the geometric properties of the circular Honai structure, measurement techniques utilized to establish dimensions and spatial organization, and the symmetrical patterns evident in its design. To ensure the credibility and reliability of the findings, data triangulation was applied by integrating insights derived from participant observation, in-depth interviews, and document analysis.

The findings were synthesized to propose a framework for integrating ethnomathematics into mathematics education. This framework seeks to bridge the traditional knowledge of the Dani community with contemporary educational practices, demonstrating how cultural heritage can serve as a resource for enriching mathematical understanding. By contextualizing the ethnomathematical insights from Honai construction within educational paradigms, this study aims to promote a deeper appreciation of cultural diversity in mathematics education and contribute to the advancement of the field of ethnomathematics.

Results and Discussion

The Construction of Honai

The initial stage in constructing a Honai involves the selection of a suitable location as shown in Figure 1. Traditionally, Honai are erected on elevated terrain to mitigate the risk of flooding. This practice reflects the ancestral knowledge of the Dani tribe, which has been transmitted across generations through oral traditions and cultural practices. Their understanding is rooted in long-term observations of rainfall patterns and water flow dynamics in the highlands. The selected site must also be level and structurally stable to ensure a robust foundation for the building. Additionally, the orientation of the Honai is a critical consideration. The entrance is conventionally oriented to face east, enabling the structure to capture the morning sunlight a tradition firmly embedded in the cultural heritage of the Dani people.

Figure 1. Land for building *honai* at Wugary village, Yalengga district, Wamena

The mathematical principles underpinning the selection and orientation of a Honai involve spatial reasoning, geometry, and measurement concepts. Spatial reasoning is utilized in evaluating the elevation and stability of the terrain to ensure it provides a secure and flat foundation. The understanding of water flow and precipitation patterns incorporates topographical principles and implicit mathematical modeling, allowing the Dani people to identify areas less susceptible to flooding based on their ancestral insights. Furthermore, the deliberate orientation of the Honai entrance towards the east reflects an application of directional geometry, derived from the observation of the sun's trajectory, which is based on a practical comprehension of the Earth's rotation. These mathematical concepts are intricately interwoven with the Dani tribe's cultural practices, illustrating an ethnomathematical approach to the Honai construction process.

The second stage in Honai construction involves procuring the required materials, which include: (a) wooden poles and planks, utilized for the frame, with durable hardwoods such as ironwood or eucalyptus favored for their strength and longevity; (b) straw or grass, employed in constructing the roof to provide insulation and waterproofing; and (c) rattan, a flexible yet resilient material used to bind the structural components as shown in Figure 2. The selection of materials by the Dani tribe is guided by criteria such as durability, flexibility, water resistance, weight, and local availability. Hardwoods are chosen for their resistance to decay, flexible materials are preferred for shaping the dome structure, and water-resistant grass is used to ensure a weatherproof roof. Additionally, materials must be lightweight to enhance structural stability and ease of construction. These decisions are informed by generations of practical observation and traditional knowledge. All materials are sourced locally, emphasizing the tribe's commitment to sustainable resource use. This practice reflects the Dani people's deep connection to their natural environment and their reliance on environmentally friendly building methods. Notably, no nails or metal components are used in constructing a Honai; instead, all elements are secured using rattan ropes or tree fibers.

Figure 2. Rattan

The mathematical principles involved in selecting materials for Honai construction encompass measurement, estimation, material properties, and optimization. The choice of durable hardwoods, flexible rattan, and water-resistant grass requires an understanding of the physical properties of materials, including strength, flexibility, and resistance to environmental factors. These properties are evaluated through experiential observation and experimentation. Estimation of material weight is also critical for ensuring stability and ease of assembly, incorporating principles of load distribution and structural balance. The exclusive use of rattan ropes or tree fibers, rather than nails or metal, demonstrates an understanding of binding techniques and tensile strength, where the forces across connections are strategically distributed. Moreover, sustainability and resource management involve mathematical reasoning, such as calculating material availability and ensuring their use does not lead to overexploitation. These practices exemplify an ethnomathematical approach, integrating mathematical reasoning with traditional ecological knowledge and resource optimization, underscoring the Dani tribe's profound understanding of their environment.

The third step in the construction of a Honai involves shaping a bare circular base using rattan. The Dani tribe utilizes locally sourced rattan, selected for its flexibility, strength, and durability against environmental conditions. The diameter of the rattan is typically small, assessed through tactile evaluation based on experience, ensuring it is sufficiently thin to bend while maintaining the necessary strength for structural binding. To create the circular base, the Dani people stand in a circle and position the rattan on the ground as shown in Figure 3. This method, passed down through generations via ancestral knowledge and observation, reflects their cultural heritage. Remarkably, the Dani people possess the skill to form a near-perfect circular base without the use of a compass or any specialized tools, relying instead on accurate estimation and practical experience. No modern technology is involved in the process.

Figure 3. Making a bare circle of Honai using rattan

The mathematical concepts applied in creating the bare circle for the Honai include geometry, proportional reasoning, and estimation techniques. The formation of the circular base demonstrates an intuitive grasp of circular geometry, as the Dani people utilize principles of symmetry and equidistance from a central point to achieve a consistent shape. Their ability to create a precise circle without modern instruments highlights their proficiency in spatial reasoning and approximation, skills honed through observation and practical application over time. The tactile assessment of the rattan's diameter embodies the principles of measurement and material analysis, ensuring the selected rattan meets the necessary criteria for flexibility and structural integrity. Additionally, the act of standing in a circle to shape the rattan implicitly applies the concepts of radius and circumference, using proportional reasoning to maintain uniformity. This process exemplifies the integration of traditional knowledge with mathematical principles, showcasing the ethnomathematical ingenuity of the Dani tribe in addressing practical construction challenges in a culturally significant manner.

The fourth stage in Honai construction involves the installation of wooden planks around the circular base, secured with rattan rope, as illustrated in Figure 4. The walls of the Honai are composed of two layers of wooden planks, with the space between the layers filled with dry grass to insulate the interior by preventing the entry of cold air. The wooden planks are tightly bound with rattan, creating a robust and stable wall capable of withstanding diverse weather conditions as shown in Figure 5. The height of the walls is carefully designed to provide adequate interior space while maintaining the Honai's compact and efficient structure.

Figure 4. Installation of wooden planks around the circular base of the Honai

The mathematical principles involved in constructing the walls of the Honai include measurement, proportionality, geometry, and structural stability. The process of installing wooden planks around the circular base requires precise spatial reasoning to ensure that the planks are evenly distributed and tightly secured, thereby preserving the structural integrity of the Honai. The height of the walls is determined by proportional reasoning and functional geometry, balancing the need for sufficient interior space with the goal of maintaining a compact design. This design minimizes heat loss while maximizing stability, exemplifying a practical application of mathematical principles to achieve a functional and resilient structure.

Figure 5. Securing wooden planks around the circular base of the Honai with rattan

The fifth step in constructing a Honai involves building the lower floor as shown in Figure 6, a straightforward yet efficient wooden structure designed to optimize space and enhance comfort. Support pillars and cross beams, typically made from durable fruitwood, are installed using traditional techniques passed down through generations. Natural materials, such as rattan, are employed to bind and secure the structure. The primary materials include sturdy local hardwood for the framework, rattan for binding, and grass or straw for insulation and the roof. The floor supports consist of wooden beams measuring 2–3 meters in length and 5–10 cm in thickness. The spacing between these beams reflects the Dani tribe's philosophy of balance and stability, ensuring even weight distribution and the efficient use of materials. This spacing is determined using traditional techniques, such as hand spans or visual alignment, guided by ancestral knowledge and practical experience, ensuring both structural integrity and functionality.

Figure 6. Construction of the lower floor of the Honai

The mathematical principles involved in constructing the lower floor include measurement, proportional reasoning, and structural stability. The dimensions of the wooden beams (2–3 meters in length and 5–10 cm in thickness) rely on precise length and thickness measurements to ensure the materials provide sufficient support while optimizing resource use. The traditional methods employed, such as hand spans and visual alignment, illustrate the application of non-standard, culturally specific measurement systems grounded in practical experience. These practices highlight the concepts of precision and estimation, as the Dani people employ intuitive methods to achieve a functional and stable design. Furthermore, geometric principles, such as symmetry and alignment, are integrated into the construction process to create a stable and efficient structure. The underlying philosophy of balance and stability reflects an ethnomathematical approach, demonstrating how ancestral knowledge and mathematical reasoning are harmonized to produce sustainable and durable designs.

The sixth step in constructing a Honai involves installing its four main pillars, with the central pillar serving as the most critical structural element as shown in Figure 7. The central pillar is crafted from solid, durable hardwood, such as ironwood or other locally sourced varieties, selected for their exceptional strength, resistance to decay, and ability to withstand challenging environmental conditions, including high humidity and heavy rainfall. The chosen wood must be straight, dense, and pest-resistant to ensure the long-term stability of the structure. To enhance the foundation, the central pillar is anchored into the ground at a depth of approximately 1 meter, providing stability and preventing displacement over time. The remaining three pillars are positioned equidistantly around the circular base to ensure even weight distribution, minimizing the risk of uneven settling or structural failure. Horizontal beams or cross-braces are used to connect the pillars, forming a robust framework capable of resisting external forces, such as wind or minor ground movements.

Figure 7. Installation of the four main pillars

Mathematical concepts are intricately embedded in the construction of the Honai, exemplifying the Dani tribe's intuitive application of fundamental mathematical principles. Beyond symmetry and geometry, proportionality plays a pivotal role in the construction process. The height of the walls and the conical roof are carefully proportioned to achieve balance and stability, enabling the structure to withstand environmental challenges such as strong winds and heavy rainfall. Measurement and estimation are also integral to the process, with traditional methods, such as using body parts (e.g., arm spans or steps) as units of measurement, showcasing the integration of practical mathematics into their craftsmanship. These methods ensure consistency in construction and demonstrate the tribe's ability to standardize and replicate structures without the use of modern measuring tools.

The construction of the Honai further reflects an advanced understanding of spatial reasoning. The strategic arrangement of materials, from the precise placement of supporting pillars to the layering of the thatched roof materials, optimizes resource utilization while ensuring functionality. For example, the overlapping roof layers are carefully designed with specific angles to prevent water seepage and provide insulation, representing a practical application of angular geometry. Additionally, ratios and scaling are employed when constructing Honai of varying sizes, such as larger communal structures or smaller individual ones. By scaling proportions while adhering to consistent design principles, the Dani people maintain structural integrity and preserve cultural continuity in their construction practices.

The Dani tribe relies on practical knowledge passed down through generations to achieve consistency in their construction techniques. Tools such as ropes and visual alignment are employed to ensure uniform pillar placement and structural uniformity. The tribe also intuitively applies the concept of load distribution, arranging the pillars and supporting beams to evenly balance the weight of the structure. This deep understanding of structural integrity, coupled with their resourceful use of locally available materials, contributes to the durability and functionality of the Honai.

These traditional practices reflect the Dani tribe's profound connection to their environment and their ability to adapt construction methods to local resources and environmental challenges. Their approach represents a harmonious integration of practical engineering, cultural heritage, and intuitive mathematical reasoning, highlighting their capacity to innovate within the context of traditional practices.

The seventh step in constructing a Honai involves building the upper floor, as depicted in Figure 8. This process includes arranging wooden cross beams to form a robust and stable floor, utilizing traditional binding techniques that have been preserved and passed down through generations within the Dani community. The upper floor is layered with dry grass, serving as an additional space for storage and sleeping. Its elevated position within the structure also enhances thermal comfort by retaining warmth more effectively.

Figure 8. Construction of the upper floor of the Honai

The mathematical concepts applied in constructing the upper floor of the Honai primarily involve geometry. The arrangement of wooden cross beams demonstrates an understanding of structural geometry, ensuring the beams are positioned to maximize stability and distribute weight evenly. These practices rely on spatial reasoning and proportionality, ensuring the upper floor is both functional and well-integrated with the overall structure of the Honai. This combination of traditional knowledge and mathematical principles exemplifies an ethnomathematical approach, where ancestral techniques are seamlessly blended with practical problem-solving methods to address construction challenges.

Once the upper floor is completed, the eighth step involves installing the roof frame. Fruitwood is tied to the main pillars and walls of the Honai, arranged in a circular pattern resembling an umbrella to form the roof, which adopts either a conical or paraboloid shape, as shown in Figure 9.

Figure 9. Installation of the roof frame

The mathematical concepts involved in constructing the roof frame include geometry and symmetry. The circular arrangement of fruitwood demonstrates an understanding of radial symmetry, where forces are distributed evenly from a central point outward. This arrangement ensures that the roof's weight is evenly supported by the structure, maintaining balance and stability. The conical or paraboloid shape of the roof reflects geometric modeling principles, as these shapes are optimized to shed rainwater efficiently and resist wind forces. Additionally, such forms are naturally stable and structurally efficient, minimizing pressure on the walls and support pillars by distributing loads evenly.

Figure 10. Covering the roof with thatch

The ninth step in the Honai construction process is covering the roof with thatch, as illustrated in Figure 10. This step involves the use of natural materials such as grass or straw, selected for their waterproofing properties, lightweight nature, and thermal insulation capabilities. The thatch is layered carefully, beginning at the bottom edge of the roof, with each subsequent layer overlapping the one beneath it. This layering technique ensures rainwater flows smoothly down the roof without penetrating the interior, reflecting the application of geometry and engineering principles.

The layering process demonstrates a clear understanding of proportionality and spatial arrangement. The consistent spacing and overlap of the layers ensure uniform coverage and eliminate gaps, enhancing the roof's durability and functionality. The thatch is arranged in a conical or paraboloid pattern, aligning seamlessly with the underlying roof frame. This requires precise measurement and alignment to maintain the roof's symmetry and functionality. With the completion of this step, the construction of the Honai is finalized as shown in Figure 11.

Figure 11. The new Honai

The construction of a Honai is a deeply intuitive process, encompassing material preparation and traditional construction techniques. The dimensions of the Honai, including its height and area, are determined through estimation, relying on the builders' experience and intuition to predict and calculate the structure's capacity upon completion. The Honai's circular design, the arrangement of the *o silimo* (closely bound and fenced together), and the round shape of the central fireplace (*wulikinmo*) symbolize the unity and familial bond of the Dani people, representing togetherness and community. The phrase "*Iniluk dapulikmo o silimo welakharek o wulikinmo*" translates to, "We all live together as one family, in one *silimo*, around one fireplace," encapsulating the cultural significance of the Honai.

The Honai is consistently constructed upon four foundational pillars, known as *hisikhe*, which hold profound religious and cultural significance. These pillars represent the Original Father, the Son (symbolizing the local Dani community), the Spirit of the ancestors, and the universe.

The roof of the Honai is typically designed in one of two shapes: conical (Figure 12) or paraboloid (Figure 13).

Figure 12. The conical roof

The circular design of the Honai reflects several fundamental philosophical principles. It serves as a testament to the preservation of cultural heritage passed down through generations, emphasizing unity and continuity. The Honai also embodies the importance of collective effort, representing the shared heart, mind, and purpose necessary for addressing challenges together. Furthermore, the Honai stands as a powerful symbol of kinship ties and functions as a sacred space for honoring and worshiping the ancestral spirits of the Dani tribe.

Figure 13. The paraboloid roof

Based on the findings presented above, several mathematical concepts can be identified:

1. Spatial Reasoning

The Dani community demonstrates exceptional spatial reasoning in conceptualizing and executing the arrangement and alignment of materials during the construction of the Honai. This includes their ability to form circular bases without modern tools, such as compasses, relying instead on intuitive understanding and traditional techniques passed down through generations. Non-standard units of measurement, such as hand spans and steps, are utilized alongside visual observation and tactile feedback to ensure precise alignment. This spatial awareness ensures the Honai's intended symmetry, stability, and functionality, particularly in the rounded base and roof design.

2. Geometry

The geometry embedded in Honai construction reflects a profound understanding of shapes and their practical applications. The circular base serves as a foundational element for structural stability, distributing forces evenly to support the roof. The roof, typically conical or paraboloid in shape, is designed to efficiently shed rainwater, reduce wind resistance, and enhance thermal efficiency. These geometric designs align not only with the functional requirements of the structure but also with the aesthetic traditions of the Dani people. The strategic arrangement of beams and the precise layering of thatch further demonstrate the use of geometric principles such as symmetry, alignment, and proportional scaling.

3. Measurement and Estimation

The Dani people employ non-standard measurement techniques, highlighting their practical approach to solving engineering challenges without modern tools. Measurements such as hand spans, steps, and visual alignment are used to determine the length of beams, spacing between supports, and thickness of thatch layers. Despite the lack of standard measuring devices, these methods require high accuracy and consistency, achieved through generations of experience and practice. Their ability to estimate dimensions and align materials precisely ensures the Honai's structural integrity, showcasing mastery of estimation as a critical mathematical skill.

4. Proportionality

Proportional reasoning plays a fundamental role in Honai construction. The Dani people carefully proportion the spacing between beams, the height of walls, and the thickness of thatch layers to the overall dimensions of the structure. For example, the height of the walls is determined to provide sufficient interior space while maintaining a compact and stable design. Similarly, thatch layers are applied with consistent overlap to ensure waterproofing without adding excessive weight to the roof. This proportionality reflects the Dani community's deep understanding of balance, functionality, and resource efficiency.

This study highlights the potential of integrating Honai construction into mathematics education. The Honai's geometric patterns, spatial dimensions, and structural relationships provide a context-rich learning environment that enhances conceptual understanding and fosters student engagement. This approach aligns with the principles of ethnomathematics, which emphasize integrating local knowledge systems into educational frameworks (Machaba & Dhlamini, 2021).

The Honai's circular base, conical or paraboloid roof, and meticulously arranged support poles offer tangible opportunities for teaching key mathematical concepts, including angles, symmetry, ratios, and scaling. Unlike abstract textbook-based methods, the hands-on exploration of the Honai allows students to intuitively grasp mathematical concepts. Furthermore, the familiarity of the Honai within students' cultural heritage bridges the gap between theoretical knowledge and real-world application, enhancing the relevance and accessibility of mathematics learning (Jablonka, 2020).

Incorporating cultural artifacts like the Honai into mathematics lessons exemplifies culturally responsive pedagogy, which has been shown to boost student motivation, reduce anxiety, and foster pride in cultural identity. For Papuan students, integrating their heritage into the classroom transforms learning into an inclusive and affirming experience, encouraging active participation and deeper engagement. For instance, discussing structural load distribution, angles formed by intersecting beams, and relationships between circumference and radius can foster critical thinking and exploration beyond rote memorization (Gilmer, 2001).

However, implementing culturally integrated teaching strategies presents challenges. Educators require adequate training in ethnomathematics and culturally responsive pedagogy to meaningfully integrate cultural elements. Without sufficient preparation, there is a risk of superficial implementation, undermining the educational and cultural significance of this approach. Additionally, scalability and adaptability are critical concerns. While the Honai is culturally significant in Dani communities, alternative artifacts may be required for students from different cultural contexts. Future research could explore similar methodologies using other artifacts, such as textiles, traditional musical instruments, or fishing tools, to broaden the scope of culturally responsive mathematics education (Barton, 1996).

Long-term studies are necessary to evaluate the impact of culturally integrated teaching strategies on students' mathematical reasoning, confidence in STEM fields, and readiness for advanced concepts. Comparative analyses between culturally integrated approaches and conventional methods would provide valuable insights into the depth and durability of learning outcomes (Martin, 2018).

This study underscores the Honai as an exemplary model of mathematical knowledge embedded within cultural practices. By integrating such culturally significant knowledge into mathematics curricula, educators can design lessons that are both mathematically rigorous and culturally affirming, representing a transformative step toward inclusive, relevant, and effective mathematics education.

Mathematical Problems based on Honai Construction

The construction of Honai offers numerous opportunities to design mathematics problems that integrate concepts such as geometric shapes, measurement, scaling, symmetry, proportionality, and spatial reasoning:

1. Geometric Shapes in the Honai Base

Problem**:**

The base of a Honai is circular with a diameter of 9 meters. Calculate:

(a) The radius of the circle.
(b) The circumference of the circle.
(c) The area of the Honai base.

2. Measurement and Scale in the Honai Model

Problem:

The actual height of the Honai is 5 meters, and the diameter of the base is 9 meters. If a scale model is created at a 1:30 scale, calculate:

(a) The height of the Honai model.
(b) The diameter of the base in the model.

3. Symmetry and Proportionality in Honai Construction

Problem**:**

The height of the Honai's conical roof is proportional to the diameter of its base at a 4:5 ratio. If the base of the Honai has a diameter of 10 meters, what is the height of the roof?

4. Spatial Reasoning in Honai Roof Construction

Problem 1**:**

The roof of a Honai is conical with a base radius of 5 meters and a height of 4 meters. Calculate:

(a) The slant height of the Honai roof.

(b) The surface area of the Honai roof.

Problem 2:

A Dani family plans to build a Honai with a diameter of 4 meters and a height of 2.5 meters. How many wooden planks, each measuring 170 cm long and 20 cm wide, will be needed to construct the Honai's wall?

The critical mathematical concepts inherent in Honai construction provide a culturally relevant framework for mathematics education. By incorporating these concepts into the classroom, educators can develop essential mathematical skills while fostering a deeper appreciation for the cultural significance of traditional architectural methods. This approach represents a promising avenue for creating more inclusive and meaningful mathematics education.

Conclusion

This study delves into the intersection of mathematics and culture by exploring the ethnomathematics embedded in the construction of Honai, the traditional house of the Dani tribe. It highlights how mathematical concepts such as geometry, spatial reasoning, proportionality, and measurement are intricately woven into the design and construction of Honai. The circular base, conical or paraboloid roof, and principles of structural integrity serve as practical examples of these mathematical applications within a culturally significant context. By examining these practices, the research demonstrates the potential of traditional knowledge to enrich mathematics education, providing students with culturally relevant and tangible examples that connect abstract mathematical concepts to real-life applications. This alignment between cultural identity and academic learning underscores the broader educational value of ethnomathematics in fostering meaningful and context-specific learning experiences.

Despite its contributions, this study is not without limitations. One notable challenge is the resource constraint, particularly in accessing and documenting traditional knowledge comprehensively. Additionally, the successful integration of Honai-inspired ethnomathematics into educational curricula may face practical barriers, such as the need for specialized teacher training and the development of culturally informed teaching materials. The research also focuses on a single cultural context, limiting its generalizability to other traditions. While this specificity allows for an in-depth exploration, it highlights the need for comparative studies across diverse cultural settings. Future research should aim to address these limitations by broadening the scope of investigation and exploring the potential of interdisciplinary collaborations to overcome practical challenges.

This study paves the way for further research into the integration of cultural artifacts in mathematics education. It recommends exploring other cultural contexts to develop a more comprehensive framework for culturally integrated learning. Future studies could investigate the long-term impacts of ethnomathematical approaches on students' academic achievements, critical thinking skills, and cultural awareness. Additionally, fostering collaboration among educators, policymakers, and cultural leaders is essential to ensure the sustainable implementation of ethnomathematics in curricula. By integrating cultural heritage into education, this innovative approach has the potential to create more inclusive, effective, and meaningful learning environments, serving as a model for other academic disciplines.

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Conflicts of Interest

The authors affirm that there are no conflicts of interest associated with the publication of this manuscript. Additionally, all ethical considerations have been meticulously addressed, including those related to plagiarism, research misconduct, data fabrication or falsification, duplicate publication or submission, and redundancies.

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