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FROM RITUAL TO REASONING: EXPLORING ETHNOMATHEMATICAL CONCEPTS IN THE NGAWU-AWU CULTURAL TRADITION

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ABSTRACT

This study aims to examine and describe the mathematical concepts embedded in the Ngawu-awu tradition in Gunung Kidul Regency as part of an ethnomathematical inquiry. The research employed a qualitative approach with an ethnographic–ethnomathematical design. The research participants consisted of traditional leaders, village elders, tumpeng makers, and community members directly involved in the implementation of the tradition, selected through purposive sampling. Data were collected through participant observation, in-depth interviews, and documentation, and subsequently analyzed using thematic analysis. The findings reveal that the Ngawu-awu tradition embodies a comprehensive application of mathematical concepts, including geometry in the arrangement of tumpeng and uborampe (cones, circles, and symmetry), arithmetic and ratios in the distribution of agricultural yields, patterns and sequences in the scheduling of agricultural rituals, as well as measurement and estimation in communal rice field cleaning activities. These findings confirm that mathematics exists as a form of contextual intelligence integrated into the cultural practices of the community. Therefore, the Ngawu-awu tradition holds significant potential to be utilized as a contextual, meaningful, and culturally grounded source for ethnomathematics-based learning.

Keywords: *ethnomathematics, Ngawu-awu tradition, cultural geometry, contextual learning*

Abstrak

Penelitian ini bertujuan untuk mengkaji dan mendeskripsikan konsep-konsep matematika yang terkandung dalam tradisi Ngawu-awu di Kabupaten Gunung Kidul sebagai bagian dari kajian etnomatematika. Penelitian ini menggunakan pendekatan kualitatif dengan desain etnografi–etnomatematika. Partisipan penelitian terdiri dari tokoh adat, sesepuh desa, pembuat *tumpeng*, dan anggota masyarakat yang terlibat langsung dalam pelaksanaan tradisi, yang dipilih melalui purposive sampling. Data dikumpulkan melalui observasi partisipatif, wawancara mendalam, dan dokumentasi, kemudian dianalisis menggunakan analisis tematik. Hasil penelitian menunjukkan bahwa tradisi Ngawu-awu memuat penerapan konsep matematika yang komprehensif, meliputi geometri dalam penyusunan *tumpeng* dan *uborampe* (kerucut, lingkaran, dan simetri), aritmetika dan perbandingan dalam pembagian hasil panen, pola dan barisan dalam penjadwalan ritual pertanian, serta pengukuran dan estimasi dalam kegiatan bersih sawah secara komunal. Temuan ini menegaskan bahwa matematika hadir sebagai bentuk kecerdasan kontekstual yang terintegrasi dalam praktik budaya masyarakat. Oleh karena itu, tradisi Ngawu-awu memiliki potensi besar untuk dimanfaatkan sebagai sumber belajar etnomatematika yang kontekstual, bermakna, dan berakar pada budaya.

Kata kunci: etnomatematika, tradisi Ngawu-awu, geometri budaya, pembelajaran kontekstual

1. INTRODUCTION

Mathematics has long been perceived as an abstract and formal discipline detached from the socio-cultural context of society [1]. Learning paradigms that emphasize symbolic procedures and rote memorization of formulas often lead students to experience difficulties in connecting mathematical concepts with real-life

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situations [2]. As a result, mathematics is frequently viewed as rigid and distant from students' lived experiences. Numerous studies in mathematics education have emphasized that decontextualized learning may reduce students' conceptual understanding, learning motivation, and critical thinking skills [3], [4]. Therefore, alternative approaches are needed to bridge formal mathematics with cultural experiences that are closely related to everyday life.

One approach that has emerged to address this issue is ethnomathematics. D'Amrosio [5] defines ethnomathematics as the study of mathematical practices that develop within specific cultural contexts, including rituals, economic activities, architecture, and social systems. This perspective views mathematics not merely as a modern academic product, but as a socially constructed body of knowledge rooted in the practical needs and cultural values of a community. Accordingly, ethnomathematics provides a framework for understanding how mathematical concepts such as geometry, arithmetic, patterns, and measurement are implicitly embedded in traditional cultural practices [6].

Within the context of Javanese culture, various agrarian ritual traditions contain rich mathematical structures, although they are not expressed through formal symbolic language. One such tradition is Ngawu-awu, which is practiced in Gunung Kidul Regency, Special Region of Yogyakarta. Ngawu-awu is an agrarian ritual involving communal rice field cleaning and expressions of gratitude for agricultural yields. The tradition encompasses several symbolic activities, including the preparation of tumpeng, the arrangement of ritual offerings (uborampe), the distribution of harvest products, and the determination of ritual schedules. These activities are not conducted arbitrarily; rather, they follow inherited rules, patterns, and calculations passed down through generations. This indicates that the Ngawu-awu tradition holds significant potential as a source of ethnomathematical inquiry that has yet to be comprehensively explored.

The preparation of tumpeng and uborampe in the Ngawu-awu tradition, for instance, represents an intuitive application of spatial and planar geometric concepts. The conical shape of the tumpeng, the use of circular tampah as its base, and the symmetrical arrangement of side dishes reflect the community's understanding of structural stability, proportion, and spatial balance. Previous studies have shown that traditional cultural artifacts often embody geometric concepts such as symmetry, transformation, and spatial partitioning that are relevant to school mathematics curricula [7], [8]. However, research that specifically examines the geometric practices embedded in the tumpeng arrangement within the Ngawu-awu tradition remains limited.

Beyond geometry, the Ngawu-awu tradition also incorporates arithmetic, ratios, patterns, and measurement within its social practices. The distribution of agricultural products reflects the use of basic arithmetic operations, fractions, and proportional reasoning grounded in principles of social justice [9]. The scheduling of agricultural rituals based on the Javanese calendar reveals numerical patterns, periodicity, and sequences that align with concepts of discrete mathematics and modular arithmetic. Meanwhile, rice field cleaning activities involve measurements of length and area, as well as estimations of time and labor. Studies by Maba et al. [10] and Pulungan et al. [11] have demonstrated that such cultural contexts are highly effective in enhancing students' conceptual understanding and mathematical modeling abilities when integrated into mathematics instruction.

Based on the above considerations, investigating ethnomathematical concepts within the Ngawu-awu tradition is both academically and pedagogically significant. This study contributes to the enrichment of ethnomathematics scholarship while providing empirical foundations for the development of culturally grounded, contextual mathematics learning. By revealing the transition "from ritual to reasoning," this research aims to demonstrate that mathematics exists as a form of contextual intelligence embedded in cultural practices, while simultaneously reinforcing the role of local traditions as meaningful and sustainable learning resources in modern mathematics education.

2. TINJAUAN PUSTAKA

2.1. Ethnomathematics

Ethnomathematics is a field of study that investigates how mathematical concepts and practices are embedded within the cultural activities of different communities. According to D'Ambrosio [12], mathematics should not be viewed solely as an abstract and universal discipline, but rather as a culturally situated knowledge system that emerges from practical needs and social interactions. This perspective highlights that mathematical thinking is present in everyday activities such as trade, craft, architecture, rituals, and agricultural practices, even if it is not formalized in symbolic notation. By exploring these cultural

expressions, ethnomathematics reveals the implicit reasoning and problem-solving strategies that communities develop to address local challenges. As a result, it provides an expanded understanding of mathematics that transcends formal classroom instruction and acknowledges the diversity of mathematical knowledge across cultures.

In educational contexts, ethnomathematics has been recognized as an effective approach for fostering students' conceptual understanding, critical thinking, and cultural awareness. Turmuzi et al. [13] and Anggraeni et al. [14] argue that integrating ethnomathematical perspectives into mathematics education helps students connect abstract concepts to real-life experiences, thereby enhancing motivation and engagement. For instance, studying patterns, measurements, and proportions within local crafts or agricultural practices allows learners to appreciate the functional and symbolic roles of mathematics in society. Furthermore, ethnomathematics contributes to preserving cultural heritage by valorizing indigenous knowledge systems as legitimate sources of learning, thereby bridging the gap between formal mathematics and the lived experiences of students.

2.2. Ngawu-awu Tradition

The Ngawu-awu tradition in Gunungkidul, Indonesia, is a culturally rich agricultural ritual that combines communal labor, symbolic offerings, and expressions of gratitude for a successful harvest. This tradition involves activities such as preparing tumpeng (cone-shaped rice offerings), arranging uborampe (side dishes), scheduling agricultural rituals, and organizing rice field cleaning. These activities are deeply structured and adhere to inherited patterns, reflecting a highly organized system of knowledge passed down through generations [15], [16]. The tradition exemplifies how cultural practices can encode implicit knowledge of mathematical concepts such as spatial arrangement, measurement, sequencing, and proportional distribution. Importantly, Ngawu-awu is not merely ceremonial; it serves practical social functions by regulating communal labor, ensuring fairness in resource distribution, and maintaining environmental sustainability.

Research has shown that such traditional practices offer valuable opportunities for educational integration. Efendi et al. [17] and Alam et al. [18] emphasizes that analyzing the rituals of Ngawu-awu allows students to explore mathematics in a meaningful cultural context. For example, the preparation of tumpeng demonstrates principles of geometry, symmetry, and proportion, while the distribution of agricultural yields highlights arithmetic, ratios, and fairness. This suggests that the Ngawu-awu tradition can be harnessed as a living curriculum that bridges cultural knowledge with formal mathematical concepts, enhancing students' engagement and comprehension. By connecting mathematics to local heritage, educators can cultivate a sense of cultural identity while simultaneously promoting numeracy skills and analytical thinking.

2.3. Cultural Geometry

Cultural geometry refers to the intuitive and applied understanding of geometric principles within the practices of a particular community. Santos [19] argues that geometry is not confined to abstract classroom exercises but emerges naturally in activities such as building construction, craftwork, ceremonial arrangements, and agricultural organization. In the context of the Ngawu-awu tradition, the cone-shaped *tumpeng* exemplifies three-dimensional geometric reasoning, while the circular layout of the base plate and the radial arrangement of *uborampe* illustrate concepts of planar geometry, symmetry, and proportional partitioning [20], [21]. These practices demonstrate that communities possess sophisticated geometric knowledge that is both functional ensuring stability and balance and symbolic reflecting cosmological beliefs and aesthetic principles.

Furthermore, cultural geometry provides a bridge between local traditions and formal mathematical education. Studies show that visual and spatial reasoning developed through cultural practices can enhance students' understanding of geometric concepts in school [22], [23]. For instance, the symmetry of food arrangements and proportional distribution in Ngawu-awu can be translated into lessons on reflective and rotational symmetry, fractions, and ratios. This approach makes abstract concepts more tangible and culturally meaningful, allowing students to engage with mathematics not only as a formal subject but also as a tool to interpret and appreciate their cultural environment.

2.4. Contextual Learning

Contextual learning emphasizes connecting academic content to real-world experiences, fostering meaningful understanding and problem-solving skills. In mathematics education, contextualized approaches have been shown to improve students' conceptual comprehension, motivation, and ability to apply

mathematical reasoning [24], [25]. By integrating cultural practices, such as rituals, craft, or traditional labor, into mathematics learning, students can see the relevance of abstract concepts in their daily lives. Contextual learning encourages learners to explore the relationships between numerical data, geometric forms, and social organization, providing a holistic understanding of mathematics as both a theoretical and practical discipline.

In the case of Ngawu-awu, contextual learning is particularly effective because the tradition inherently incorporates measurable, structured, and patterned activities. The arrangement of *tumpeng* and *uborampe*, the distribution of harvest yields, and the scheduling of agricultural rituals all offer concrete examples of geometry, arithmetic, ratios, and sequences. Incorporating these activities into classroom instruction allows learners to engage in problem-solving that is culturally meaningful while developing their computational and spatial reasoning skills [26], [27]. This not only strengthens conceptual learning but also fosters cultural appreciation, demonstrating how mathematics is intertwined with heritage and everyday life.

3. METHOD

This study employed a qualitative approach with an ethnographic–ethnomathematical design aimed at examining and describing the geometric concepts embedded in the arrangement of tumpeng and uborampe within the Ngawu-awu tradition in Gunungkidul Regency. The research participants consisted of traditional leaders, village elders, tumpeng makers, and community members directly involved in the implementation of the tradition, selected through purposive sampling. Data were collected through participant observation during the Ngawu-awu ritual, in-depth interviews to explore the philosophical meanings and technical aspects of tumpeng construction, and documentation in the form of photographs, videos, and field notes. The collected data were analyzed using thematic analysis, involving data reduction, data display, and conclusion drawing, and were subsequently linked to formal geometric concepts such as cones, circles, reflection symmetry, and rotational symmetry. Data credibility was ensured through source and technique triangulation [28], [29]. Through this process, the study is expected to provide a comprehensive understanding of the relationship between Ngawu-awu cultural practices and geometric concepts as part of ethnomathematics research.

4. RESULTS AND DISCUSSION

4.1. Results

4.1.1. Geometric Concepts in the Arrangement of Tumpeng and Uborampe

The arrangement of tumpeng in the Ngawu-awu tradition is a tangible representation of the application of solid geometry, specifically the properties of a cone. Physically, the upward-tapering shape of the tumpeng is not merely an aesthetic choice but a symbol of the vertical relationship between humanity and the Creator, which in mathematics is represented by the apex (peak). Technically, the tumpeng possesses geometric elements consisting of the base radius (r), the height of the cone (h), and the slant height (s). Precision in maintaining the inclination of the slant height is vital to ensure the rice structure remains sturdy and does not collapse, which mathematically relates to the ratio between its height and base diameter.

On the other hand, the use of a tampah (a traditional circular tray) as the base for the tumpeng introduces the concept of plane geometry in the form of a perfect circle. The surface area of this tray serves as the base plane where the weight of the tumpeng is distributed and the uborampe (side dishes) are arranged. The placement of side dishes around the tumpeng typically follows a constant distance from the center of the circle (the radius), thereby forming concentric patterns. Geometrically, this arrangement divides the circular plane of the tray into several sectors (juring), the areas of which are often regulated to appear balanced, reflecting a profound understanding of proportional spatial division.

The aesthetic and philosophical aspects of the tumpeng are also closely linked to the principles of reflectional (line) symmetry and rotational symmetry. The arrangement pattern of the side dishes is often designed such that if a straight line is drawn through its center, one side becomes a mirror image of the other, demonstrating reflectional symmetry. Furthermore, if the tray is rotated around its central axis, the sequence and density of the side dishes remain harmonious from various perspectives (rotational symmetry). This geometric balance does not only create a visually pleasing harmony but also symbolizes the equilibrium between the elements of the universe in Javanese cosmology, expressed through precise mathematical calculations.

4.1.2. Arithmetic and Ratios in Harvest Distribution

The Ngawu-awu tradition is a vivid manifestation of the application of social arithmetic within community life, where abundant harvests are managed through meticulous calculation. This distribution process begins with the recording of the total quantity of agricultural produce collected, which is then processed using basic arithmetic operations, such as addition for calculating totals and division for distribution. In this context, mathematics serves as an instrument for maintaining social order; every grain of the harvest must be accurately accounted for so that the distribution process to the villagers can proceed without discrepancies. This principle ensures that all communal assets to be shared have clear documentation before entering the more complex stages of allocation.

Furthermore, the concepts of ratio and proportionality are at the heart of the values of justice upheld in this tradition. The distribution of the harvest is often not carried out in an identical nominal fashion but rather proportionally based on specific criteria, such as the number of family members in a household or the level of a villager's contribution during the farming process. This reflects the use of ratios in mathematics, where the portion received by an individual is directly proportional to variables of need or entitlement. This proportional justice ensures that every individual receives an adequate share, which can be mathematically calculated using direct proportions to ensure a balance between available resources and the number of recipients.

Additionally, the distribution of singular physical objects, such as the nasi tumpeng or the gunungan (mountain-shaped harvest offerings), is closely related to the concept of fractions. When a whole tumpeng is sliced to be shared among dozens or hundreds of villagers, each slice represents a fractional value of the whole (1). An intuitive understanding of numerators and denominators arises when community leaders ensure the number of slices is sufficient for all attendees. The ratio between the number of slices and the total base area or total volume of the rice is a practical application of geometry and arithmetic, ensuring that social harmony is maintained through a transparent and mathematically accountable distribution.

4.1.3. Patterns and Sequences in Agricultural Ritual Schedules

The execution of the Ngawu-awu ritual in Javanese agricultural traditions is a clear manifestation of the concepts of periodicity and mathematically structured number patterns. These rituals are not performed at random; rather, they follow a fixed time cycle based on the Javanese calendar or plant growth phases. In mathematics, this regularity can be viewed as an arithmetic sequence, where the days the rituals are held represent terms (U_n) that appear with a constant common difference or interval (d). For example, a ritual performed every selapan (35 days) forms a number pattern with a precise interval, allowing the community to predict and prepare for all ritual requirements well in advance.

Moreover, this scheduling is often linked to the Pranata Mangsa system, an ecological calendar that divides a year into specific periods based on natural phenomena. The correlation between the positions of constellations, animal behavior, and the ritual schedule creates a complex repeating pattern (cycle). If we were to map the ritual dates over a year, we would find a harmonious sequential structure. Understanding these patterns helps students realize that ancestral traditions are actually early forms of mathematical modeling used to understand the order of the universe. This teaches that order is not merely an abstract concept on paper but a life guide for maintaining ecosystem balance.

In an educational context, analyzing the Ngawu-awu ritual schedule helps sharpen computational thinking through pattern recognition. When villagers determine an auspicious day for Ngawu-awu by combining the seven-day week (Saptawara) and the five-day market cycle (Pancawara), they are essentially operating with the concepts of the Least Common Multiple (LCM) or modular arithmetic. The patterns resulting from the interaction of these two different cycles create a stable rhythm of life. By studying how sequences and series work within this ritual schedule, we can see that mathematics is the language used by traditional societies to synchronize human activities with the periodic laws of nature.

4.1.4. Measurement and Estimation in Rice Field Cleaning

The activity of cleaning the rice fields in the Ngawu-awu tradition serves as a natural laboratory rich in the application of length and area measurement. Before cleaning begins, farmers typically observe the dimensions of their fields, which are often rectangular or trapezoidal in shape. Measuring the distance between embankments (galengan) is crucial to ensure that irrigation flow is not obstructed and land boundaries are maintained. Mathematically, farmers intuitively calculate the perimeter of the land to

determine the amount of labor needed to clean the edges, as well as the total area to estimate the volume of weeds or harvest residue to be cleared. The use of traditional units of area, such as uabin or bahu, which are converted into square meters (m^2), acts as a bridge between local wisdom and formal mathematics.

Beyond physical measurement, the aspects of estimation and time management play a vital role in the efficiency of communal labor (gotong royong) during this tradition. The community must be able to estimate the time required to complete a plot of land based on the number of participants. This estimation involves variables of individual work speed (productivity) multiplied by the total number of workers. If the land area is known and the average hourly work capacity has been estimated, the villagers can determine the appropriate start and break times so the ritual can be completed before sunset. The ability to estimate accurately is not just a technical skill but a form of practical intelligence that ensures social coordination runs harmoniously without overburdening any party.

Integrating rice field cleaning activities into contextual mathematics learning provides a profound understanding of proportionality and precision. Students are invited to see that numbers on paper have a tangible impact on the lives of agrarian societies. For instance, when calculating the ratio between land area and the requirement for water or organic fertilizer after cleaning, students learn about the interdependence between variables. The concept of estimation also teaches that in the real world, there is a margin of error that must be managed. Through the Ngawu-awu tradition, mathematics is no longer viewed as a rigid and abstract subject, but as a living tool used by ancestors to achieve effectiveness in managing nature and strengthening brotherhood through measured collective work.

4.2. Discussion

The arrangement of tumpeng in the Ngawu-awu tradition of Gunung Kidul demonstrates that three-dimensional geometric concepts have long been practiced contextually within traditional community life. The conical shape of the tumpeng represents the community's intuitive understanding of stable and proportional geometric structures. Elements of a cone such as the circular base, height, and slant height are applied empirically to maintain the physical balance of the tumpeng and prevent structural collapse [30], [31], [32]. This finding is consistent with), who asserts that mathematical practices embedded in local cultures often emerge as implicit, functional knowledge rather than formal symbolic representations. Therefore, the tumpeng in the Ngawu-awu tradition can be understood as a concrete representation of ethnomathematics, in which abstract geometric concepts are embodied through culturally meaningful and technically grounded practices.

Furthermore, the use of a tampah as the base of the tumpeng introduces planar geometry in the form of a circle, which serves both structural and aesthetic functions. As a base, the circular shape distributes the weight of the tumpeng evenly, thereby maintaining its stability. The arrangement of uborampe on the tampah also reflects a deliberate spatial organization through circular sectors of relatively equal area. This finding aligns with the study by Hatmoko [33], Rochmat et al. [34] and Rosa [35] which revealed that spatial organization in traditional cultural activities often reflects an intuitive understanding of area, angles, and proportionality. In this context, the Ngawu-awu community is not merely arranging food items but is simultaneously applying principles of planar geometry that are highly relevant to school mathematics curricula.

The aspect of symmetry in the arrangement of side dishes surrounding the tumpeng further reinforces the relationship between cultural aesthetics and formal mathematical concepts. The consistent emergence of reflective symmetry and rotational symmetry indicates an awareness of visual balance and spatial order within the community. Junandi [36], Barton [37] and Kuswantara [38]emphasizes that symmetry found in traditional cultural artifacts is a strong indicator of mathematical thinking that develops naturally within societies. In the Ngawu-awu tradition, symmetry serves not only to enhance visual appeal but also to symbolize harmony and cosmic order within the Javanese worldview. This demonstrates that mathematics and cultural values are not separate entities, but rather mutually reinforcing elements within social practice.

From an educational perspective, these findings support previous studies suggesting that the integration of ethnomathematics enhances students' conceptual understanding. Research by Susanti et al. [23], Nu',man et al. [39]and Limori wt al.[40] indicates that incorporating local cultural contexts into geometry instruction increases student engagement and improves spatial visualization skills. The process of arranging tumpeng in the Ngawu-awu tradition can therefore be utilized as a concrete learning medium for teaching concepts such as cones, circles, symmetry, and proportionality in a more meaningful manner. Through this approach,

students not only learn formulas for volume or surface area, but also understand the functional and philosophical rationale underlying geometric forms.

In conclusion, the geometric concepts embodied in the arrangement of tumpeng and uborampe within the Ngawu-awu cultural tradition affirm that mathematics is an integral part of cultural life. This finding strengthens the ethnomathematical perspective that mathematical knowledge evolves from the practical needs and social values of a communit [14], [41], [42]. Linking mathematics learning to local traditions such as Ngawu-awu not only enriches students' conceptual understanding but also contributes to cultural preservation and the strengthening of local identity. Consequently, the Ngawu-awu tradition holds significant potential as a contextual, meaningful, and culturally grounded source of learning.

5. CONCLUSION

The Ngawu-awu tradition embodies a comprehensive and integrated application of mathematical concepts within community life, encompassing geometry in the arrangement of tumpeng and uborampe, arithmetic and ratios in the distribution of agricultural yields, patterns and sequences in the scheduling of agricultural rituals, and measurement and estimation in rice field cleaning activities. These practices demonstrate that mathematics does not exist merely as abstract knowledge, but rather as contextual intelligence rooted in practical needs, principles of social justice, and the Javanese philosophy of life.

It is recommended that the mathematical concepts embedded in the Ngawu-awu tradition be systematically utilized as a source of ethnomathematics-based learning in schools, particularly to enhance students' conceptual understanding, contextual reasoning skills, and appreciation of local culture. Furthermore, the development of instructional materials and further research examining the effectiveness of integrating the Ngawu-awu tradition into formal mathematics education are necessary to ensure that local wisdom is preserved while simultaneously contributing meaningfully to the improvement of educational quality

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