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Ethnomathematics of the religious beliefs and rituals of the Bagobo Tagabawa of Southern Mindanao, Philippines

Dexter G. Gabica*, University of the Philippines Cebu, Philippines,
*e-mail: dggabica@up.edu.ph (corresponding author)

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Abstract: This study examines the ethnomathematical dimensions of the religious beliefs and ritual practices of the Bagobo Tagabawa of Southern Mindanao. Grounded in ethnographic analysis and informed by ethnomathematics theory, it investigates how mathematical ideas are embedded, enacted, and transmitted through culturally meaningful religious activities. Drawing on field observations, elder narratives, and ethnographic and ethnomedical literature, the study analyzes ritual practices such as pilgrimage to Apo Sandawa, spatial organization of ritual spaces, healing practices involving the preparation of *lana*, symbolic offerings, music, and dance. Findings show that these practices embody systematic mathematical concepts including geometry, measurement, ratio and proportion, sequencing, patterning, and cyclicity. Mathematical reasoning among the Tagabawa is expressed through embodied movement, spatial design, material preparation, and collective coordination, and is inseparable from cultural values of balance, reciprocity, and harmony. The study highlights the pedagogical potential of Tagabawa ethnomathematics for culturally responsive and place-based mathematics education and contributes to efforts to decolonize mathematics education by recognizing indigenous rituals as legitimate sites of mathematical knowledge.

Keywords: ***Ethnomathematics, indigenous knowledge, mathematics education, Bagobo Tagabawa, religious rituals***

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INTRODUCTION

Ethnomathematics is an interdisciplinary field that examines how mathematical ideas are generated, represented, and transmitted within specific cultural contexts. First articulated by D'Ambrosio (1997), ethnomathematics challenges the long-standing assumption that mathematics is culturally neutral and universal, arguing instead that mathematical knowledge is a human construction shaped by social practices, belief systems, historical experiences, and interactions with the natural environment. From this perspective, activities such as counting, measuring, locating, designing, classifying, and

patterning emerge organically from cultural life rather than exclusively from formal schooling (Bishop, 1988).

In mathematics education, ethnomathematics has been increasingly recognized as a powerful framework for promoting equity, relevance, and cultural responsiveness. Scholars have argued that students develop deeper conceptual understanding when mathematical ideas are connected to familiar cultural practices and lived experiences (Rosa & Orey, 2011; Barton, 2008). This approach is especially important in indigenous contexts, where dominant Western mathematical paradigms have historically marginalized local knowledge systems and ways of knowing (Gerdes, 1999; Powell & Frankenstein, 1997).

In the Philippine context, ethnomathematics holds particular relevance due to the country's rich cultural and linguistic diversity. Indigenous peoples across Luzon, Visayas, and Mindanao demonstrate sophisticated mathematical thinking embedded in agriculture, weaving, architecture, music, rituals, navigation, and healing practices (Alangui, 2010; Lausa, 2017). Despite this, formal mathematics education in the Philippines has largely remained anchored in Western traditions, often overlooking indigenous epistemologies. This disconnect contributes to issues of cultural alienation and limits the potential of mathematics education to be inclusive and meaningful (Bernardo, 2004; Valero, 2010).

Among the indigenous groups of Mindanao, the Bagobo Tagabawa represent a community whose religious beliefs and ritual practices reveal deeply embedded systems of ordering, structuring, and meaning-making that align closely with ethnomathematical ideas. The Tagabawa traditionally inhabit the areas surrounding Mount Apo, locally known as Apo Sandawa, which they regard as the most sacred landscape in their cosmology (Quizon, 2007). Their worldview integrates spirituality, nature, health, and community life, resulting in ritual practices that are highly structured in space, time, quantity, and proportion.

Extensive ethnographic and ethnomedical research has documented the cultural life of the Bagobo Tagabawa, particularly in relation to health, healing, and religious practices (Payne, 1985; Paluga et al., 2013). The Phase II Documentation of Philippine Traditional Knowledge and Practices on Health conducted by researchers from the University of the Philippines Mindanao and University of the Philippines Manila provides a comprehensive account of Tagabawa ethnopharmacology, ritual healing, and religious organization, particularly the *Lanahan* or Apo Sandawa Sarili Langis religious group (Paluga et al., 2013). While these studies richly describe Tagabawa culture, they do not explicitly examine religious practices through an ethnomathematical lens.

This study addresses this gap by examining the religious beliefs and ritual practices of the Bagobo Tagabawa as sites of ethnomathematical knowledge. Specifically, it aims to: (1) describe the general profile and religious worldview of the Bagobo Tagabawa; (2) analyze key ritual practices in terms of their embedded mathematical ideas; and (3) discuss the pedagogical potential of these ethnomathematical elements for culturally responsive mathematics education. The study contributes to broader efforts to decolonize mathematics education and to recognize indigenous epistemologies as legitimate sources of mathematical knowledge (D'Ambrosio, 2001).

METHOD

This study employed a qualitative research design grounded in ethnographic methodology. Ethnography is particularly appropriate for investigating indigenous knowledge systems because it prioritizes prolonged engagement, cultural immersion, and the interpretation of meanings from the perspective of community members themselves (Hammersley & Atkinson, 2007). Rather than isolating variables, ethnography seeks to understand practices as part of an integrated cultural whole.

The analysis draws from field-based ethnographic documentation conducted in one of the Bagobo Tagabawa communities in Southern Mindanao, Philippines. The research was guided by an ethnographic orientation that prioritizes prolonged engagement, contextual understanding, and the interpretation of meaning from the perspectives of community members. Data collection methods included participant observation, informal and semi-structured interviews with elders, ritual leaders, and healers, focus group discussions with community members, and photographic documentation of ritual spaces, artifacts, and practices. These methods enabled the capture of both observable ritual activities and the cultural interpretations that inform them.

Participant observation allowed the researcher to document the spatial organization, sequencing, and embodied practices involved in rituals, while interviews and focus group discussions provided access to emic explanations of ritual rules, symbolism, and values. Photographic documentation served as a supplementary tool for recording spatial arrangements and material culture relevant to the analysis of ethnomathematical structures.

Ethical considerations were central throughout the research process. Informed consent was obtained from participants, cultural protocols governing access to sacred knowledge were strictly observed, and sensitive information was handled with care to

avoid misrepresentation or misuse. The study adhered to ethical principles for research involving indigenous communities, emphasizing respect, reciprocity, and cultural sensitivity.

To situate the ethnographic findings within broader scholarly discourse, secondary sources such as peer-reviewed journal articles and ethnographic monographs on ethnomathematics and indigenous education were reviewed. Foundational works on ethnomathematical theory and culturally grounded mathematics education provided the analytical lens for interpreting the data (Bishop, 1988; Gerdes, 1999; Rosa & Orey, 2011).

Data analysis followed a thematic approach informed by ethnomathematical theory, allowing cultural practices to be examined as sites of mathematical meaning-making. Field notes, interview narratives, and visual documentation were systematically reviewed and coded to identify recurring patterns related to space, quantity, proportion, symmetry, sequencing, timing, and classification. Initial coding focused on descriptive features of ritual practices, such as movement patterns, spatial arrangements, material quantities, and procedural order. These codes were then clustered into broader analytical themes corresponding to fundamental mathematical activities identified in ethnomathematical literature, including counting, measuring, locating, designing, and patterning (Bishop, 1988).

Interpretive analysis was guided by D'Ambrosio's (1997) conceptualization of ethnomathematics as culturally situated mathematization, wherein mathematical thinking emerges through everyday practices rather than formal symbolic representation. Patterns identified in the data were interpreted not as isolated behaviors but as coherent systems of reasoning embedded within Tagabawa religious life. Attention was given to how these mathematical ideas were enacted through embodied practice, material preparation, and social coordination, and how they were sustained through cultural norms and values. This analytical process ensured that interpretations remained grounded in ethnographic evidence while being theoretically informed, enabling a nuanced understanding of mathematics as embedded in cultural practice rather than abstract cognition alone.

RESULTS AND DISCUSSION

General Profile of the Bagobo Tagabawa Community

The ethnographic study was conducted in one of the communities of the Bagobo Tagabawa in Southern Mindanao, Philippines. The Bagobo Tagabawa are an indigenous ethnolinguistic group belonging to the Manobo family, traditionally inhabiting the eastern and southern slopes of Mount Apo (Quizon, 2007; Paluga et al., 2013). Field-based

accounts and community narratives consistently portray Mount Apo (*Apo Sandawa*) as the geographical and spiritual center of Tagabawa life. It is not simply a landmark but a living sacred space that structures social organization, religious practice, and collective identity.

The Bagobo is one of the largest groups among the indigenous people in Southern Mindanao. They are on Malayan descent who brought Hinduism in Mindanao. The Bagobo is divided into three groups, namely, the Tagabawa, the Clata and the Ubo. Though they are generally of the same linguistic group, they differ in their traditions, dialects and culture (Mangune, 2015). Bagobos are situated around Mt. Apo as the mountain is considered to be the sacred place of worship since time immemorial and valued as the group's richest cultural heritage. By origin, they are nomadic as they travelled from place to place in search of food and crops, however, most of the Bagobo tribes have already settled in, and mostly surrounding the area of Mt. Apo.

The subject of this research was from the subgroup of Bagobo Tagabawa. *Bawa* means south, so roughly, they are referred to as the people of the south. The community in one of the barangays of a province of Southern Mindanao was considered as a rural community with majority of the land area protected as ancestral land by the National Commission of Indigenous People (NCIP). There was a total of 248 households recorded in the barangay.

Observations documented in the UP Mindanao–UP Manila report indicate that Tagabawa social organization is anchored in relational leadership. Elders , ritual leaders, and healers derive authority from spiritual knowledge, ritual competence, and moral standing rather than from formal political hierarchy (Paluga et al., 2013). Decision-making observed during communal gatherings reflects consensus-oriented processes, where participation and agreement are valued over unilateral authority.

The community where the study was conducted had a well-defined social structure since before which had the members assigned with roles based on their recognized skills and talents. The community was headed by a chieftain called *Matanum* and was supported by the Council of Elders as the consultants, jurors and advisers in the community. *Matanum* were chosen by the community based on the leadership quality. Important part of their structure was the *magani or bagani*, who takes charge of the peace and order in the community.

They still had their Matanum, and they had allowed a woman to lead their community. However, the community was already part of the barangay, so they had adapted the current political structure in the Philippines and participated the barangay election. The number one *kagawad* (councilor) and three other councilors were Bagobo Tagabawa. Though Bagobo Tagabawa were represented already in the barangay council through the *kagawads*, the *Matanum* still were consulted in terms of activities and decisions that would affect the Bagobo traditions. She, the *Matanum*, led the whole community and carried their voice, and represented the community in the NCIP indigenous people gathering which would forge camaraderie and friendships among all the indigenous community in Davao. There was no specific Council of Elders, but the elders still served as a consultative group of decisions that would affect the community. The community maintained their connection to other Bagobo Tagabawa community during different celebrations and communal feasts.

The community still maintained close family ties as most members were related in blood in one way or another. Though there were already mixed marriages with non-Bagobos, the communal relationship amongst family was still evident based on the location of their houses. First-degree family members were settling in one area or near each other. In a communal area, they had high regard to their elders. The wisdom of *tugál mama* (old man) and *tugál bayi* (old woman) still was considered as knowledge by the community. They helped each other in terms of doing the livelihood and shared whatever the harvest. Figure 1 showed one communal area with six families.

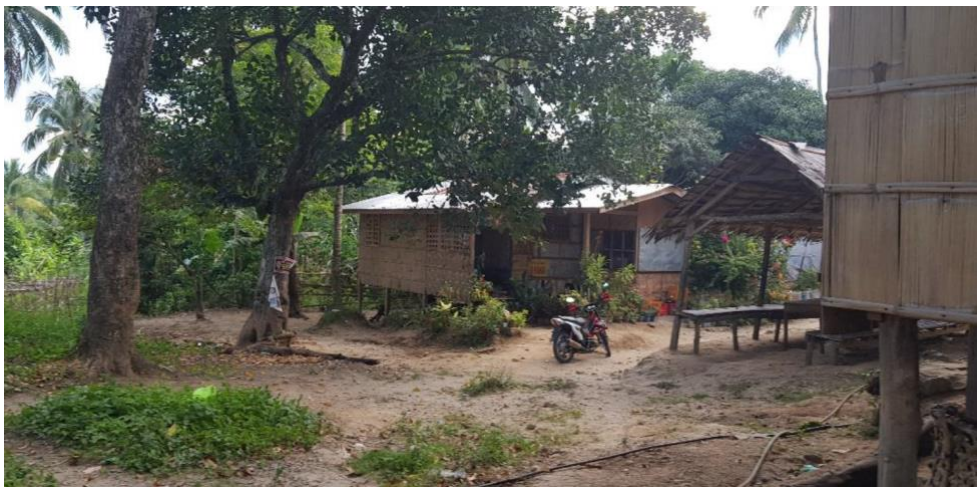

Figure 1. One of the communal communities of six families

Most of the Bagobo Tagabawa members already adapted to the modern way of living from the way they dress to the structure of their houses. Traditional dresses were only worn on celebrations and special occasions and most of the households did not have any unless there was an elder or someone who had a position in the community.

Most houses near the barangay hall reflected a fusion of the old and the new way of constructing houses. However, a 20-minute walk further in would bring you to a communal area where most of the elders were staying in a typical and traditional house called *balé* (see Figure 2). Houses were made of bamboo, *amakan, nito, batikan,* and cogon grass. It was a bungalow-typed house where the upper floor served as the bedroom and the lower area was for dining and kitchen (see Figure 3). They still cooked in traditional way using coconut husks or chopped woods.

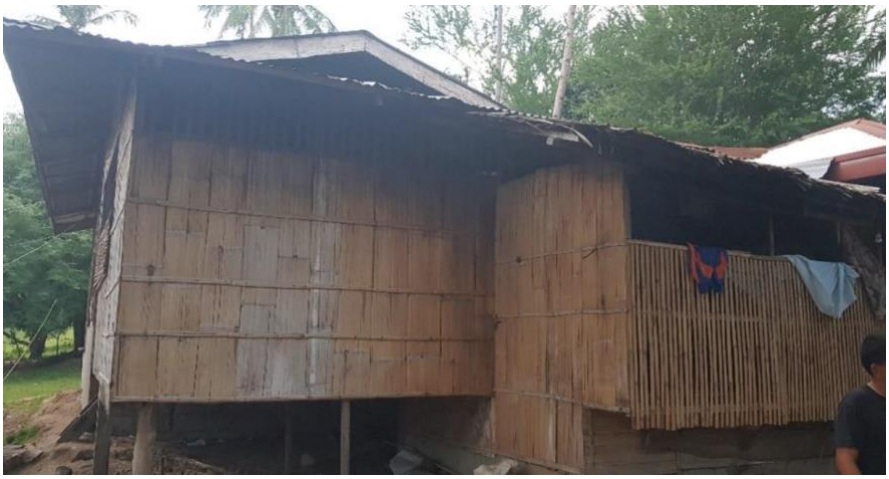

Figure 2. The *balé* (house) of one of the elders, a typical house of Bagobo Tagabawa

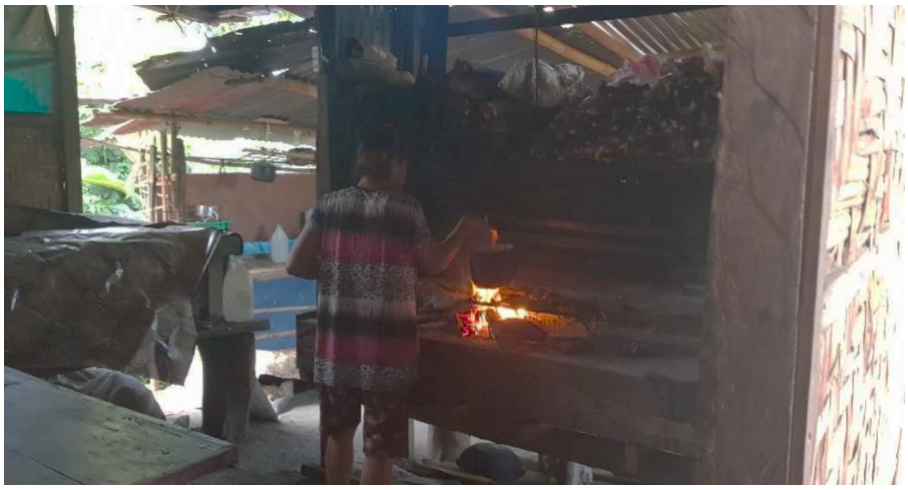

Figure 3. The kitchen and dining area at the lower part of the house

Livelihood practices observed among the Tagabawa are primarily agrarian, complemented by abaca production, weaving, and small-scale trade. These practices are carefully synchronized with environmental cycles, such as rainfall patterns, soil conditions, and seasonal changes (Quizon, 2007). Elders emphasized that successful farming depends on correct timing and observation, revealing an applied understanding of temporal measurement, sequencing, and pattern recognition. Such knowledge supports ethnomathematical claims that mathematical thinking emerges from practical engagement with the environment (Bishop, 1988; Gerdes, 1999).

Religious Beliefs of the Bagobo Tagabawa

Ethnographic data and existing literature consistently describe Bagobo Tagabawa religious beliefs as animistic and deeply nature-centered. Although most members of the community have undergone baptism into Catholic or Protestant traditions, field observations and prior studies indicate that a significant number of Tagabawa continue to practice ancient forms of nature worship alongside Christianity. This syncretic religious landscape reflects the persistence of indigenous cosmology, wherein spiritual forces are believed to permeate the natural environment and actively influence human life (de Jong, 2010; Payne, 1985; Paluga et al., 2013).

Central to Tagabawa cosmology is the belief in a single supreme creator known as *Pamulak Manobo*, sometimes referred as *Manama,* who governs the universe and authorizes the presence and actions of numerous spirits inhabiting mountains, forests, rivers, stones, and plants. These spirits are not understood as abstract or distant beings but as spatially situated entities embedded within the landscape. Field narratives emphasize that sacred places such as *Apo Sandawa* (Mount Apo) are regarded as the dwelling place of powerful spirits, including *Mandarangan*, often described as a warlord spirit associated with strength and conflict. In contrast, *Sandawangan*, a smaller black mountain, is believed to confine *Meybuyan*, an evil spirit guarding the underworld. This spatial differentiation of spiritual domains reinforces a worldview in which moral and cosmological order is mapped onto physical geography (de Jong, 2010).

A key conceptual structure repeatedly articulated by elders is the distinction between *baloy-banwa* (the visible human world) and *dakel banwa* (the unseen spiritual world). These realms are understood to be interconnected and mutually influential. Health, illness, fortune, and misfortune are interpreted as outcomes of balanced or disrupted interactions between them. In the University of the Philippines ethnomedical documentation, illness is frequently attributed to spiritual imbalance, neglect of ritual obligations, or improper conduct toward spirits and sacred spaces (Paluga et al., 2013). Healing rituals, offerings, and pilgrimages are therefore not merely therapeutic acts but corrective mechanisms aimed at restoring equilibrium between these domains.

This cosmological framework reflects a systems-oriented understanding of causality and balance. Rather than attributing events to isolated causes, the Tagabawa conceptualize life as the result of interacting forces operating across visible and invisible realms. From an ethnomathematical perspective, such reasoning parallels mathematical notions of equilibrium, feedback, and interdependence, where changes in one component of a system affect the behavior of the whole (Bishop, 1988; Valero, 2010).

Ritual celebrations further reveal how this worldview is enacted through structured social practices. Community gatherings involving music, dance, feasting, and the wearing of ceremonial clothing are organized to honor spirits during key life events such as planting, harvesting, marriage, and healing. These rituals follow prescribed sequences, spatial arrangements, and symbolic quantities, reinforcing the idea that order and balance must be actively maintained. The use of hand-woven textiles known as *inábal* during special occasions also reflects patterned design, symmetry, and repetition, extending mathematical ideas into material culture and aesthetic expression. Women traditionally wear *ompák ka báyi* as an upper garment and *sónnod* as a skirt, while men wear *ompák ka máma* paired with knee-length trousers called *saroár* (Quizon, 2007). These garments are worn during important gatherings, including town celebrations and ritual pilgrimages to Apo Sandawa, reinforcing their role as markers of sacred time and collective identity. Beadworks attached to *inábal* often represent elements of Tagabawa cosmology, livelihood, and ritual practice. Certain motifs function as narrative symbols: a stick-like human figure may depict a rain ritual, while repeated corn stalk designs symbolize planting and harvesting cycles. Detailed beadwork on the *saroár* frequently represents agricultural abundance, while the simpler yet deliberate designs on the *ompák ka báyi* have been described as visual representations of the night sky (Quizon, 2007). These motifs reveal an implicit understanding of repetition, scaling, symmetry, and spatial mapping, where patterns are arranged systematically to convey meaning.

Most woven and embroidered designs directly reflect farming activities and agricultural products, illustrating how mathematical thinking is intertwined with subsistence practices and environmental awareness (see Figure 4). The repetition of plant-based motifs, the balanced distribution of beads, and the alignment of figures across the textile surface demonstrate concepts of equivalence, periodicity, and proportional spacing. Such design practices parallel mathematical pattern recognition and transformation, supporting ethnomathematical scholarship that identifies weaving and textile production as key sites of indigenous mathematical knowledge (Bishop, 1988; Gerdes, 1999).

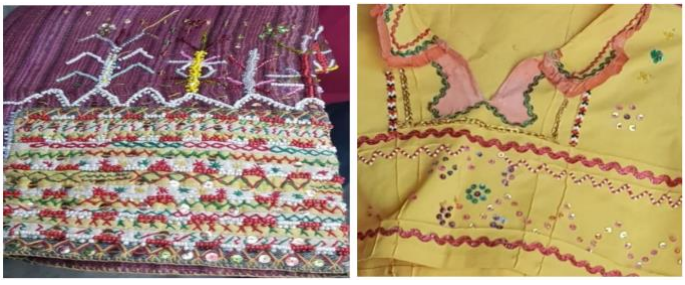

Figure 4. The beadworks on *saroár* (left) and on *ompák ka báyi* (right)

From an ethnomathematical standpoint, the dual-world framework of *baloy-banwa* and *dakel banwa* functions as a cognitive model that organizes reality into interacting domains. This structuring is analogous to mathematical modeling, where complex phenomena are understood through relationships among variables within a system. In the Tagabawa context, mathematical thinking is inseparable from cosmology, ethics, and environmental awareness, reinforcing the view that mathematics is not merely a technical discipline but a culturally grounded way of making sense of the world (D'Ambrosio, 1997; Gerdes, 1999; Valero, 2010). Additionally, the integration of ritual celebration, material culture, and textile design reinforces the view that Tagabawa mathematics is enacted across multiple domains of life—ritual, agriculture, art, and social organization. Mathematical ideas are not isolated abstractions but are embedded in the rhythms of communal life, the cycles of farming, and the aesthetics of ceremonial expression. This further affirms the ethnomathematical claim that mathematics is culturally situated and that indigenous communities such as the Bagobo Tagabawa actively generate, preserve, and transmit mathematical knowledge through lived practice rather than formal schooling (D'Ambrosio, 1997; Rosa & Orey, 2011).

Pilgrimage and Spatial Sequencing to *Apo Sandawa*

The *Lanahan* or *Apo Sandawa Sarili Langis* pilgrimage to Mount Apo stands out as one of the most mathematically structured religious practices observed among the Bagobo Tagabawa. Both elder narratives and the University of the Philippines ethnomedical documentation describe the pilgrimage as a highly regulated collective movement governed by spatial order, procedural discipline, and symbolic alignment with the sacred landscape (Paluga et al., 2013). Participation in the pilgrimage is not merely a physical journey but a carefully orchestrated process in which space, movement, and sequence are imbued with spiritual significance.

Field observations indicate that pilgrims move in organized formations, maintaining consistent spacing while following a prescribed path toward *Apo Sandawa*. The route is punctuated by ritual stops known as *serbis*, each associated with specific prayers, offerings, and moments of reflection. Elders emphasized that the sequence of these stops must not be altered, as each *serbis* corresponds to a particular stage of spiritual preparation. Skipping, rearranging, or shortening any part of the sequence is believed to weaken the ritual's efficacy.

One elder articulated this principle clearly:

> "Sa among pagpanlakaw paingon sa Apo Sandawa, naa gyud mi sundon nga linya ug distansya. Dili pwede magdikit-dikit o magbulag-bulag kay simbolo na sa panaghiusa."
> (*When we walk toward Mount Apo, we follow a specific line and distance. We must not crowd or scatter because this symbolizes unity.*)

This narrative highlights how spatial order is not incidental but essential to the ritual's meaning. From an ethnomathematical perspective, the pilgrimage reflects concepts of linearity, alignment, distance, and ordered sequencing. The path itself is conceptualized as a series of stages that must be completed in a fixed order, forming what can be interpreted as an algorithmic structure. Each *serbis* functions as a checkpoint, analogous to steps in an algorithm where progression depends on the successful completion of prior actions. Such hierarchical ordering is central to mathematical logic and procedural reasoning (Gerdes, 1999).

Furthermore, the maintenance of equal spacing among participants demonstrates an embodied understanding of uniform distribution and balance. Although distances are not measured using standardized units, spacing is regulated through shared visual cues, bodily awareness, and collective adjustment. Pilgrims constantly negotiate their positions relative to one another, ensuring neither excessive proximity nor excessive separation. This reflects a form of non-numerical measurement rooted in social coordination and cultural norms, supporting Barton's (2008) argument that spatial measurement often emerges from communal practices rather than formal instruments.

The insistence on straight-line movement and coordinated pacing also reflects geometric reasoning. Alignment along a single path reinforces notions of directionality and orientation, while synchronized movement expresses symmetry and cohesion. Elders explained that physical unity during the pilgrimage symbolizes moral and spiritual unity, suggesting that mathematical order is inseparable from ethical and social values within Tagabawa cosmology. Importantly, the pilgrimage also involves temporal sequencing. Specific segments of the journey are undertaken at designated times of day, reinforcing the importance of rhythm and pacing. This integration of spatial and temporal order reflects a holistic form of mathematical reasoning in which distance, sequence, and timing are interdependent rather than isolated concepts.

Taken together, the *Apo Sandawa* pilgrimage exemplifies how mathematical thinking is embedded in ritual movement and landscape engagement. The Tagabawa do not abstract these ideas into symbols or formulas; instead, they enact them through

disciplined bodily practice and shared cultural understanding. This supports ethnomathematical theory asserting that mathematical reasoning is not confined to formal schooling but is deeply rooted in culturally meaningful activities that structure how people move, count, measure, and organize experience (D'Ambrosio, 1997; Gerdes, 1999; Barton, 2008).

Ritual Spaces and Geometry

Ritual spaces among the Bagobo Tagabawa are not arranged arbitrarily but are the result of deliberate spatial planning grounded in cosmological belief, ritual function, and communal values. Field observations and elder narratives consistently identified the *rasyon* as a critical ritual space—an extension of the main worship hall where offerings to ancestral spirits and spirits of nature are made visible and accessible. The *rasyon* serves as a liminal zone between the human and spiritual realms, and its spatial organization reflects this mediating role.

At the center of the *rasyon* (see Figure 5) is the altar, constructed in a square formation using bottles placed at equal distances from one another. Elders explained that the square shape is intentional, symbolizing fairness, balance, and completeness. No side is longer than the other, and no corner is given preference, reinforcing the belief that all spirits must be treated equally during offerings. One elder described this principle succinctly:

> "Kung pantay ang porma sa altar, pantay pud ang among paghatag. Walay labaw, walay kulang."
> (*When the shape of the altar is even, our offering is also even. No one is favored, no one is lacking.*)

Figure 5. The square shaped altar in the *rasyon*

From a mathematical standpoint, the square altar exemplifies several core geometric concepts. Its equal sides and right angles reflect symmetry and congruence, while the evenly spaced bottles form an array-like structure. Such arrangements correspond to early forms of spatial structuring and equal partitioning, foundational ideas in geometry and arithmetic (Bishop, 1988). The use of equal spacing—achieved without rulers or measuring devices—demonstrates embodied measurement based on visual estimation and collective agreement, reinforcing ethnomathematical findings that measurement often emerges through cultural practice rather than formal units (Gerdes, 1999).

The functional design of the altar further reveals applied mathematical reasoning. The intentional gaps between bottles allow liquid offerings—such as blood from livestock or water from harvested crops—to flow continuously into the soil. This reflects practical reasoning about continuity, flow, and spatial optimization. The arrangement balances symbolic meaning with physical functionality, showing how geometric design is informed by both spiritual values and material constraints.

Above the square altar is an open rectangular roof structure positioned directly overhead (see Figure 6). Elders explained that this opening allows sunlight to reach the offerings so that the spirits can "see" what has been given. This vertical alignment creates a clear spatial relationship between the altar and the sky, reinforcing the belief that communication with the divine occurs through direct visibility. Mathematically, this configuration forms a tangible example of inscribed and circumscribed figures: the square altar is inscribed within the rectangular roof opening, while the roof circumscribes the altar below.

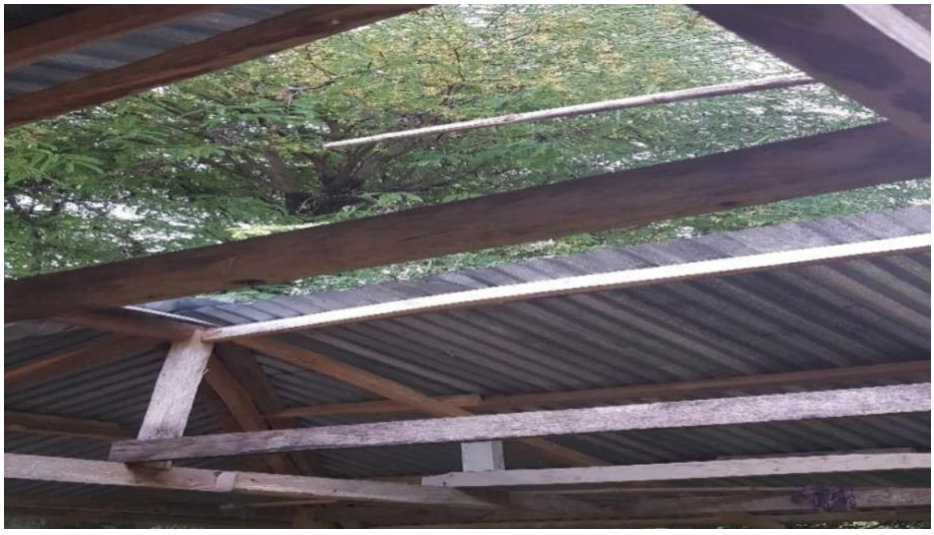

Figure 6. The open rectangular roof directly above the altar

This spatial relationship illustrates geometric concepts such as area, perimeter, alignment, and proportionality. The rectangular opening must be sufficiently large to fully encompass the square altar, requiring implicit reasoning about size relationships and spatial containment. Such reasoning aligns with Rosa and Orey's (2011) assertion that geometric ideas are often embedded in cultural artifacts and spatial designs long before they are formalized in school mathematics.

The orientation of the *rasyon* itself also reflects geometric intentionality. The placement of the altar relative to the worship hall, surrounding benches, and open ground creates a structured spatial hierarchy that guides movement and participation during rituals. Participants naturally position themselves around the altar in ways that preserve symmetry and balance, reinforcing collective awareness of spatial order.

The *rasyon* and its associated structures demonstrate that geometric reasoning among the Bagobo Tagabawa is not abstract or decorative but deeply functional, symbolic, and ethical. Geometry becomes a means of expressing balance, fairness, and harmony—values central to Tagabawa cosmology. These findings support ethnomathematical scholarship emphasizing that mathematical ideas are culturally situated and that spatial reasoning is inseparable from meaning-making within indigenous contexts (D'Ambrosio, 1997; Gerdes, 1999; Rosa & Orey, 2011).

Healing Processes and Proportional Reasoning

Healing rituals among the Bagobo Tagabawa provide some of the clearest and most concrete manifestations of applied mathematical reasoning embedded in everyday religious practice. Ethnographic observations and the attached ethnomedical documentation reveal that the preparation of *lana*—a sacred healing oil—is governed by strict procedural rules involving balance, sequencing, timing, and proportional judgment (Paluga et al., 2013). Unlike symbolic or spatial forms of ethnomathematics, healing practices demand precision because incorrect preparation is believed to result not only in ineffective medicine but also in spiritual imbalance.

The preparation of *lana* typically involves combining coconut oil, volcanic sulfur sourced from Mount Apo, and specific medicinal plants such as *salese* and *wahig*. Elders consistently emphasized that no single ingredient should dominate the mixture. One healer explained the process in experiential terms:

> "Kung sobra ang asupre, init kaayo ang lana. Kung kulang, dili na mosulod ang bisa. Kinahanglan gyud balanse ra."
> (*If the sulfur is too much, the oil becomes too hot. If it is too little, the potency will not take effect. It really has to be balanced.*)

This statement reflects a sophisticated, practice-based understanding of ratio and proportion. Rather than relying on numerical measurement tools or fixed units, healers use embodied estimation developed through repeated practice and apprenticeship. Quantities are judged by visual cues, texture, smell, and prior experience, demonstrating what ethnomathematics scholars describe as non-symbolic proportional reasoning (Gerdes, 1999). Such reasoning parallels early mathematical thinking, where relationships between quantities are understood relationally rather than through formal calculation.

The process also involves iterative adjustment. Healers may add small amounts of an ingredient incrementally, continuously reassessing the mixture's properties. This mirrors mathematical ideas of approximation and error correction, where values are refined through successive estimation. From a mathematical perspective, this reflects informal concepts of continuous variables and proportional adjustment, even though these ideas are not expressed symbolically.

Temporal regulation further reinforces the mathematical structure of healing practices. Ethnographic accounts emphasize that ingredients must be gathered only at specific times and under particular conditions. Water used in the preparation of *lana* may be collected from mountain springs, while certain components are gathered only after receiving spiritual permission. Particularly significant is the use of the first rain in May, referred to as *unang salod ka ulan ka Mayo*. These practices demonstrate cyclical reasoning and calendar-based organization. The Tagabawa conceptualize time not as a linear, continuous scale but as a cycle marked by seasonal transitions and spiritually significant moments. Such temporal structuring aligns with mathematical concepts of periodicity and cyclic functions, where events recur according to patterned intervals. This supports Bishop's (1988) assertion that counting and measuring time are fundamental cultural activities through which mathematical ideas emerge.

Additionally, the sequential order of ingredient collection and mixing reflects procedural logic. Each step must be completed in the correct order—collecting ingredients, preparing the base oil, adding components gradually, and performing accompanying prayers. Deviating from this sequence is believed to disrupt both the healing process and the spiritual balance it seeks to restore. This mirrors algorithmic thinking, where outcomes depend on the correct execution of ordered steps (Barton, 2008).

Importantly, proportional reasoning in *lana* preparation is inseparable from ethical and cosmological values. Balance is not merely a technical requirement but a moral principle tied to harmony between humans, nature, and the spirit world. Mathematical relationships are thus embedded within a broader value system that prioritizes moderation, respect, and reciprocity. This finding aligns with ethnomathematical scholarship emphasizing that mathematical thinking is culturally situated and often inseparable from ethical and spiritual meaning (D'Ambrosio, 1997; Rosa & Orey, 2011).

Symbolic Quantities, Counting, and Patterns

Symbolic use of quantity is a recurring feature of Bagobo Tagabawa ritual practice, where numbers function simultaneously as tools for enumeration and carriers of cultural meaning. Ethnographic observations and elder narratives indicate that numerical values are rarely arbitrary; instead, they are selected for their symbolic resonance within the Tagabawa worldview. One of the most frequently observed examples is the use of five-cent or five-peso coins during offerings, explicitly associated with the five fingers of a clenched fist, symbolizing responsibility, commitment, and collective strength.

An elder explained this symbolism as follows:

> "Ang lima ka sensilyo nagpasabot sa lima ka tudlo sa kamot. Kung magkuyom ang kamot, lig-on. Mao pud na among panag-uyon ug responsibilidad."
> (*The five coins represent the five fingers of the hand. When the hand is clenched, it is strong. That is also our unity and responsibility.*)

From a mathematical perspective, this practice demonstrates the dual nature of numbers as both quantitative and symbolic entities. The value "five" is not merely counted but interpreted, reinforcing ethnomathematical arguments that numerical concepts are culturally constructed and embedded in meaning (D'Ambrosio, 1997; Bishop, 1988). This integration of symbolism and quantity challenges the notion that numbers are neutral abstractions, showing instead that counting practices can encode ethical and social values.

The preparation and distribution of *lana* further reinforce ideas of uniformity and equivalence. Ethnographic documentation shows that bottles of *lana* are prepared in equal numbers and distributed evenly among participants or households. This practice reflects an implicit understanding of fairness and equal partitioning, corresponding to mathematical concepts of equivalence and one-to-one correspondence. Although no explicit counting devices are used, the consistent outcome indicates reliable enumeration practices grounded in shared expectations and social regulation.

Attendance records and contribution lists observed during communal rituals serve as additional sites of applied counting and classification. Names, offerings, and responsibilities are recorded to ensure accountability and collective participation. These practices involve forming sets (e.g., participants, contributors, households), counting elements within each set, and categorizing individuals based on roles or contributions. From an ethnomathematical viewpoint, these activities correspond to foundational ideas in set theory, classification, and data organization (Bishop, 1988).

Music and dance introduce another layer of mathematical structure through patterns, rhythm, and repetition. Instruments such as the agung are commonly arranged in sets—often eight gongs—producing interlocking rhythmic sequences. Each gong contributes a distinct sound that fits within a larger rhythmic cycle. The resulting musical patterns exhibit repetition, alternation, and periodicity, reflecting core mathematical ideas related to cycles and sequences.

Dance movements observed during rituals further reinforce these mathematical ideas. Steps follow fixed sequences, often repeated in symmetrical formations around a central space. Movements alternate between left and right, advance and retreat, creating visual patterns that mirror rhythmic cycles in the accompanying music. These embodied patterns exemplify mathematical concepts of symmetry, repetition, and transformation enacted through the body rather than written symbols.

Such findings align with Barton's (2008) assertion that pattern recognition and repetition are central to mathematical thinking across cultures. Among the Tagabawa, these concepts are learned not through formal instruction but through participation, observation, and imitation, highlighting the role of embodied cognition in mathematical understanding.

Pedagogical Potential of Tagabawa Religious Practices

The expanded findings of this study underscore the significant pedagogical potential of Bagobo Tagabawa religious practices for mathematics education, particularly within culturally responsive and place-based learning frameworks. These practices demonstrate that mathematical ideas are not confined to formal schooling but are deeply embedded in culturally meaningful activities. By situating mathematics instruction within indigenous contexts familiar to learners, educators can transform mathematics from an abstract discipline into a lived and relational experience (Rosa & Orey, 2011; Lausa, 2017).

Tagabawa rituals offer authentic contexts for teaching a wide range of mathematical concepts, including geometry, measurement, ratio and proportion, sequencing, and pattern recognition. Because these concepts arise naturally within ritual practice, they allow learners to engage with mathematics through observation, participation, and reflection rather than rote memorization. This approach aligns with ethnomathematical perspectives that emphasize learning mathematics as a cultural activity rooted in experience (D'Ambrosio, 1997).

Concrete examples from Tagabawa ritual life illustrate this pedagogical potential clearly. The square altar in the *rasyon* can be used to explore geometric concepts such as area, perimeter, symmetry, and arrays. Students may be guided to analyze why the altar is square rather than rectangular, examine equal spacing between bottles, and calculate areas or perimeters based on observed dimensions. Such activities allow geometry to be taught through culturally meaningful structures rather than decontextualized diagrams.

Similarly, pilgrimage routes to Apo Sandawa provide rich opportunities for teaching spatial reasoning, mapping, distance, and algorithmic thinking. The sequence of *serbis* can be translated into step-by-step procedures, flowcharts, or ordered lists, helping learners understand algorithms as culturally grounded processes rather than purely computational constructs. Mapping the pilgrimage route can also introduce coordinate systems, scale, and directional concepts in ways that connect mathematics to geography and history.

The preparation of *lana* offers an especially powerful context for teaching ratio and proportion. Learners can examine how balance among ingredients affects outcomes, model mixtures using fractional relationships, and explore how proportional reasoning applies across mathematics and science. This integration encourages interdisciplinary learning and demonstrates that mathematics plays a crucial role in health, sustainability, and environmental knowledge.

Music and dance further extend the pedagogical value of Tagabawa practices. Rhythmic patterns produced by instruments such as the agung and structured dance movements provide embodied experiences of fractions, cycles, repetition, and symmetry. Counting beats, identifying repeating patterns, and analyzing rhythmic sequences enable learners to experience mathematical structures through movement and sound, supporting embodied cognition and multimodal learning.

Equally important is the Tagabawa mode of knowledge transmission, which emphasizes observation, participation, repetition, and mentorship by elders. Learning occurs through guided practice rather than explicit instruction, with novices gradually

developing competence by watching and imitating experienced practitioners. This mode of learning aligns closely with constructivist theory, which emphasizes the active construction of knowledge through experience (Vygotsky, 1978), and with experiential learning theory, which highlights learning through reflection on action (Kolb, 1984).

Incorporating these pedagogical principles into formal education supports culturally responsive teaching by validating indigenous ways of knowing and learning. Rather than positioning indigenous knowledge as supplementary or peripheral, this approach recognizes it as foundational to understanding mathematical concepts. Such recognition contributes to the decolonization of mathematics education by challenging Eurocentric assumptions about how mathematics is learned and who produces mathematical knowledge (Smith, 2012). Table 1 showcases a summary of mapping from religious rituals to mathematical concepts and classroom applications.

Table 1. Mapping of Bagobo Tagabawa Rituals to Mathematical Concepts and Classroom Applications

Ritual / Practice	**Ethnographic Observation**	**Embedded Mathematical Concepts**	**Possible Classroom Applications**
Lanahan/Apo Sandawa Sarili Langis pilgrimage	Linear group movement, fixed ritual stages	Linearity, distance, sequencing, algorithms	Route mapping, flowcharts, procedural problem-solving
Serbis (ritual stops)	Ordered prayer and offering points	Ordered sets, intervals, ordinal numbers	Number lines, sequences, ordering activities
Rasyon (offering area)	Centrally organized sacred space	Geometry, symmetry, area, perimeter	Shape analysis, area and perimeter computation
Square altar with bottles	Equal spacing and balanced layout	Arrays, equal partitioning, congruence	Arrays, multiplication, equal groups
Rectangular roof opening above altar	Spatial alignment of roof and altar	Inscribed and circumscribed figures, proportionality	Composite shapes, spatial reasoning
Lana preparation (healing ritual)	Balanced mixture of oil, sulfur, plants	Ratio, proportion, estimation, mixtures	Ratio and proportion problems, interdisciplinary math–science tasks
Timing of ingredient collection	Seasonal and ritual-based timing	Cycles, time measurement, periodicity	Calendars, cyclic patterns, time graphs

Ritual / Practice	Ethnographic Observation	Embedded Mathematical Concepts	Possible Classroom Applications
Offerings and attendance lists	Fixed quantities and social accountability	Counting, sets, classification, one-to-one correspondence	Set theory basics, data organization
Music and Ritual Dance	Repeated rhythmic patterns and movements	Patterns, repetition, cycles, symmetry	Fractions, rhythmic sequences, pattern analysis
Inábal textile weaving	Loom-woven cloth with repeated motifs	Patterning, tessellation, translation	Pattern creation, tiling activities
Embroidery on *inábal*	Repeated and mirrored bead designs	Reflection, symmetry, congruence	Line symmetry, mirror images
Beadwork motifs (corn stalks, figures)	Repeated symbolic designs	Translation, scaling, proportional spacing	Transformations, scale drawings
Color arrangements in textiles	Structured use of maroon and accent colors	Patterns, ratios, visual balance	Ratio of colors, pattern recognition
Ceremonial clothing (*ompák ka báyi*, *sónnod*, *saroár*)	Symmetrical garment construction	Symmetry, measurement, proportion	Measurement activities, design geometry
Radial bead patterns (night sky motifs)	Circular and central designs	Rotation, rotational symmetry, angles	Rotational symmetry, angle measurement

CONCLUSION

This study has demonstrated that the religious beliefs and ritual practices of the Bagobo Tagabawa constitute a coherent and systematic body of ethnomathematical knowledge deeply grounded in lived experience, spirituality, and communal life. The mathematical ideas enacted through pilgrimage, spatial design, healing practices, symbolic offerings, music, and dance are structured, rule-governed, and conceptually rich. Through these practices, the Tagabawa articulate mathematical concepts related to geometry, measurement, ratio and proportion, sequencing, patterning, and cyclicity in ways that are both functionally effective and culturally meaningful. The findings further reveal that mathematical reasoning among the Tagabawa is inseparable from cultural values such as balance, reciprocity, harmony, and responsibility. These values shape how space is organized, how materials are prepared, how movements are coordinated, and

how quantities are determined. Mathematics, in this context, operates not merely as a technical tool but as an ethical and relational practice that sustains social cohesion and cosmological order. This challenges dominant Western conceptions of mathematics as culturally neutral and reinforces ethnomathematical perspectives that view mathematics as a human activity shaped by worldview, history, and context. This study further contributes to the preservation and validation of indigenous knowledge systems that have long been marginalized in formal education. It highlights the pedagogical relevance of Tagabawa ethnomathematics for culturally responsive and place-based mathematics education, offering meaningful pathways for integrating indigenous knowledge into the curriculum. The study underscores the need to broaden conceptions of mathematics by recognizing indigenous communities not as passive recipients of mathematical knowledge, but as active creators of mathematical meaning embedded in culture, practice, and everyday life.

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