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Exploring the mathematics of the Sinulog Festival

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Abstract: This study documents mathematical knowledge embedded in the Sinulog Festival through an ethnomathematical lens. Addressing the limited empirical documentation of cultural practices as mathematical systems, the research employed a qualitative ethnographic design over six months of fieldwork in Cebu City. Data were collected through repeated observations, semi-structured interviews with three key festival practitioners (choreographer, logistics coordinator, and historian), artifact analysis, and visual documentation. Thematic coding identified recurring mathematical domains across choreography, costume and prop design, and logistical planning. Findings reveal systematic applications of symmetry, geometric transformations, proportional reasoning, counting systems, measurement, estimation, and optimization. These practices demonstrate that mathematical reasoning operates as functional knowledge within communal cultural performance rather than solely within formal schooling. The study provides empirical evidence that large-scale festivals constitute structured mathematical environments and offers a grounded basis for integrating culturally situated contexts into mathematics education while maintaining conceptual rigor.

Keywords: Ethnomathematics, Sinulog Festival, cultural relevance, mathematics education

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INTRODUCTION

Mathematics education aspires to cultivate learners capable of reasoning, modeling real situations, and applying quantitative thinking beyond the classroom. Yet in practice, mathematics is frequently presented as a system of abstract symbols and procedural routines detached from everyday experience. This disjunction contributes to persistent perceptions of mathematics as difficult, culturally neutral, and disconnected from lived reality. When mathematical concepts are taught without meaningful context, understanding risks becoming mechanical rather than conceptual. The challenge, therefore, is not only instructional but epistemological: How is mathematical knowledge recognized, legitimized, and situated?

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Ethnomathematics offers one response to this question. Initially articulated by D'Ambrosio (1985), ethnomathematics argues that mathematical knowledge emerges within cultural practices and community problem-solving rather than solely within formal academic systems. Counting, measuring, designing, navigating, organizing space, and optimizing resources are not merely technical procedures; they are culturally embedded forms of reasoning. From this perspective, mathematics is neither universal in expression nor independent of social context, but rather enacted through human activity (d'Entremont, 2015). Similarly, constructivist learning theory posits that understanding develops through active engagement with meaningful experiences (Hein, 1991). Culturally relevant pedagogy further emphasizes that connecting instruction to learners' identities and communal practices enhances both engagement and achievement (Ladson-Billings, 1995). Collectively, these perspectives challenge the view of mathematics as detached abstraction and instead frame it as lived, contextualized knowledge.

Empirical studies increasingly support this position. Research on indigenous crafts, architectural designs, games, and traditional artifacts has demonstrated sophisticated uses of symmetry, proportional reasoning, geometric transformation, and spatial organization embedded in everyday cultural production. Recent Scopus-indexed bibliometric analyses reveal a marked growth in ethnomathematics scholarship over the past decade, with expanding geographic representation and methodological diversity (Pradana, et al., 2022; Turmuzi, et al., 2024). Contemporary literature reviews likewise document efforts to translate ethnomathematical insights into classroom materials and instructional frameworks, highlighting their potential to strengthen conceptual understanding and learner engagement (Batiibwe, 2024; Wulandari, et al., 2024). These syntheses confirm that ethnomathematics has moved from theoretical advocacy toward empirical and pedagogical application.

Despite this expansion, important gaps remain. Much of the documented research focuses on small-scale cultural artifacts—textile patterns, handicrafts, traditional games, or architectural motifs. While these studies effectively reveal mathematical structures within material culture, fewer investigations examine large-scale, collective cultural performances that require coordinated spatial, quantitative, and logistical reasoning. Public festivals constitute complex environments where geometry, measurement, estimation, optimization, and proportional design operate simultaneously. Organizing such events demands systematic planning of space, time, and resources. Choreographed performances require precise formation changes, spatial partitioning, rhythmic counting, and synchronized transformations. Costume and prop design involve scaling, pattern

replication, tessellation, and structural balance. Logistical coordination entails budgeting, scheduling, route mapping, crowd estimation, and risk management. These activities reflect integrated mathematical reasoning enacted within communal celebration.

The relative absence of large-scale festival studies within ethnomathematics literature represents a conceptual and empirical gap. Festivals are often analyzed for their historical, religious, or sociocultural significance, yet rarely examined as structured mathematical systems. As a result, the complexity of quantitative and spatial reasoning embedded in such events remains under documented in mathematics education research. This oversight limits both scholarly understanding of culturally situated mathematics and the development of authentic curricular contexts derived from community practice.

The Sinulog Festival in Cebu City provides a compelling case for addressing this gap. As one of the Philippines' largest annual religious and cultural celebrations, Sinulog features synchronized street dances, elaborate costumes and prop designs, and extensive logistical coordination. Dance contingents form geometric configurations—circles, grids, triangular and linear arrays—while executing coordinated rotations, reflections, and translations. Designers replicate motifs symmetrically and proportionally across costumes and headdresses. Organizers allocate budgets, manage participant counts, schedule performances, and optimize parade routes under spatial and temporal constraints. These practices collectively constitute a naturally occurring environment in which mathematical reasoning is operational, embodied, and socially distributed.

Guided by ethnomathematics and constructivist perspectives, this study investigates the Sinulog Festival as a site of mathematical practice. Specifically, it asks: What mathematical knowledge, practices, and skills are embedded in the festival's choreography, material design, and logistical organization? By documenting these structures through qualitative inquiry, the study aims to contribute empirical evidence that extends current ethnomathematics scholarship beyond artifact-focused analyses toward large-scale communal performance contexts. In doing so, it also provides a grounded foundation for exploring how culturally situated mathematical reasoning may inform more meaningful mathematics instruction without compromising disciplinary rigor.

Through systematic documentation of mathematical domains enacted within Sinulog, this research advances three contributions: first, it broadens the scope of ethnomathematical inquiry to include complex festival environments; second, it demonstrates how mathematical reasoning operates integratively across spatial, quantitative, and organizational domains; and third, it offers a contextually anchored case

study from Southeast Asia, addressing regional underrepresentation within global ethnomathematics literature. By situating mathematics within lived cultural performance, the study affirms that mathematical thinking is not external to community life but is actively constructed through it

METHOD

This study employed a qualitative ethnomathematical design grounded in ethnographic fieldwork (Creswell & Poth, 2018). The objective was to document and interpret mathematical reasoning embedded in naturally occurring cultural practices rather than to test predefined variables. The design was descriptive–interpretive, focusing on identifying systematic patterns of counting, measurement, spatial organization, proportional reasoning, and optimization within festival activities.

Field-based ethnographic inquiry was adopted to capture mathematical practices within their authentic setting. This approach allowed direct observation of performances, rehearsals, and preparation activities and enabled interaction with participants responsible for choreography, design, and organization. The study emphasized documenting actions and procedures as they occurred rather than relying solely on retrospective accounts.

Purposive sampling was used to select key informants occupying decision-making roles where mathematical reasoning was operationally evident. Three participants were included: A head choreographer (dance contingent leader), A logistics coordinator, A festival historian involved in planning and documentation.

Each had a minimum of three years of active involvement in the festival. Pseudonyms were assigned to ensure confidentiality. While the number of participants was limited, each occupied a central decision-making role, enabling in-depth access to structurally significant practices rather than surface-level observations.

Data were gathered using:

1. Observation protocols for recording spatial arrangements, movements, and measurements.
2. Semi-structured interview guides focusing on planning processes, estimation strategies, and design procedures.
3. Field notes documenting rehearsals and meetings.
4. Photographs and video recordings of formations, costumes, and routes.
5. Document artifacts such as sketches, route maps, schedules, and layout plans.

Data collection occurred over six months, covering pre-festival preparation, rehearsal, and the main celebration. The researcher conducted repeated site visits during rehearsals and planning sessions. Non-participant observations were first carried out to record formations, spacing, counts, and movement patterns. Measurements such as estimated distances between performers and stage dimensions were noted.

Semi-structured interviews lasting 30–45 minutes were subsequently conducted with each participant to clarify how decisions were made (e.g., spacing calculations, pattern design, crowd estimation). Interviews were audio-recorded with consent and transcribed verbatim. Photographs and videos were used to supplement descriptions and verify spatial configurations. Field notes were written immediately after each session to preserve contextual detail.

Data analysis followed a hybrid thematic coding procedure combining inductive and theory-informed approaches. Initial open coding identified recurring practices involving spatial organization, measurement, sequencing, proportionality, and resource allocation. These codes were then grouped into higher-order categories aligned with ethnomathematical domains. Visual data were analyzed to confirm geometric properties such as symmetry, congruence, and transformation. Documentary artifacts were examined to identify quantitative reasoning in scheduling, estimation, and route planning.

Triangulation across interviews, observations, and artifacts enhanced credibility. Member checking was conducted by sharing summarized interpretations with participants to confirm descriptive accuracy. An audit trail of coding decisions and analytic memos was maintained to support transparency and dependability. Written informed consent was obtained before participation. Identifying details were removed from transcripts and visual materials. Data were stored securely and used exclusively for research purposes.

RESULTS AND DISCUSSION

Analysis revealed that mathematical reasoning within the Sinulog Festival operates across three interrelated domains: embodied spatial reasoning, proportional-patterned design, and distributed quantitative coordination. Rather than isolated numerical instances, these domains reflect integrated ethnomathematical systems enacted collectively.

Embodied Spatial–Geometric Reasoning

Dance formations consistently exhibited geometric organization, including circular arrays, linear alignments, triangular configurations, and grid-like partitions.

Spacing was determined using embodied units ("arm-lengths"), functioning as informal measurement systems. Leaders adjusted formations according to available street width, demonstrating proportional partitioning of space.

Transformational sequences, such as rotation, translation, and reflection, occurred rhythmically and collectively. These movements correspond to formal geometric transformations but were enacted kinaesthetically rather than symbolically. Geometry in this context functioned as operational knowledge necessary for synchronization and collision avoidance. From an ethnomathematical perspective, this reflects spatial reasoning embedded in communal coordination (Barton, 1996). The findings align with constructivist views that conceptual understanding may originate in embodied experience before formal abstraction.

Proportional and Patterned Design Systems

Costume and prop production revealed structured pattern replication and proportional scaling. Artisans partitioned fabrics symmetrically and replicated motifs radially and bilaterally. Enlarged decorative elements preserved ratio relationships to smaller prototypes, demonstrating similarity and proportional reasoning.

Pattern repetition followed arithmetic sequencing in colour and bead placement. Tessellated surfaces and radial symmetry in shields and headdresses further evidenced systematic geometric construction. These practices illustrate that algebraic and geometric reasoning can be embedded within aesthetic production without formal notation. Mathematical thinking operated as procedural fluency guided by balance, equivalence, and invariance.

Distributed Quantitative and Optimization Reasoning

Festival organization required systematic quantitative planning. Participant counts, schedule intervals, material estimation, and route selection involved arithmetic operations, ratio considerations, and iterative adjustments. Route planning considered crowd density and walking speed, reflecting informal modeling and optimization under constraints. Budget allocation demonstrated proportional distribution of limited resources across competing categories. This domain illustrates mathematics as distributed cognition—reasoning embedded within coordinated organizational processes rather than individual calculation alone.

Integrated Ethnomathematical Structures and Curricular Implications

Cross-domain analysis revealed three recurring mathematical structures: (1) spatial partitioning and transformation, (2) proportional scaling and patterned replication, and (3) quantitative modeling under constraint. These structures operated integratively rather than as isolated curricular topics, reflecting mathematics enacted within communal practice (D'Ambrosio, 2001; Rosa & Orey, 2016).

Spatial Partitioning and Transformation

Choreographic formations required systematic partitioning of space into circular, linear, triangular, and grid configurations. Spacing was maintained using embodied measurement units, while synchronized rotations, translations, and reflections preserved structural symmetry. These practices demonstrate geometric reasoning concerning congruence and invariance under transformation.

Spatial reasoning did not occur independently. Adjustments to formations required proportional recalibration when performer numbers or performance space changed, illustrating the coordination of measurement and ratio reasoning. Within formal curricula, such practices correspond to geometry and coordinate transformations; in practice, they functioned as operational necessities embedded in collective movement. This embodied enactment of geometry aligns with constructivist accounts of spatial cognition emerging from meaningful activity (Hein, 1991).

Proportional Scaling and Patterned Replication

Costume and prop construction exhibited systematic proportional reasoning and pattern regularity. Motifs were replicated bilaterally and radially, and scaled elements preserved ratio relationships across varying dimensions like arithmetic sequencing, structured color patterns, and bead placement.

These processes reflect similarity, tessellation, and ratio as organizing principles rather than abstract rules. As documented in recent ethnomathematics syntheses, culturally embedded design practices frequently operationalize proportional and geometric reasoning without formal notation (Batiibwe, 2024; Pradana *et al*., 2022). In curricular terms, these correspond to algebraic patterning and similarity, yet in practice, they functioned within a unified design system.

Quantitative Modeling Under Constraint

Festival logistics required estimation, proportional allocation, scheduling, and route optimization under spatial and temporal constraints. Participant counts, budget distribution, and route selection involved iterative adjustments resembling informal

mathematical modeling. Decision-making incorporated arithmetic operations and constraint-based reasoning distributed across roles.

Recent reviews note increasing attention to modeling and applied reasoning within ethnomathematical contexts (Turmuzi *et al*., 2024; Wulandari *et al*., 2024). The Sinulog case extends this trend by demonstrating such reasoning within a large-scale communal performance rather than small-scale artifacts.

Integrative Structure

Across domains, mathematical reasoning operated simultaneously rather than sequentially. Geometry intersected with proportionality, and measurement-informed transformation, while modeling integrated arithmetic with optimization. This integrative structure (Table 1) contrasts with the compartmentalization typical of school curricula and supports the view of mathematics as socially situated and functionally coherent (D'Ambrosio, 2001; Rosa & Orey, 2011).

Table 1. Integrated Ethnomathematical Structures Observed in the Sinulog Festival

Domain	Observed Practices	Underlying Mathematical Structures	Curriculum Correspondence
Choreography	Spatial formations; synchronized transformations	Partitioning, symmetry, rotation, translation, proportional spacing	Geometry; coordinate reasoning
Costume & Props	Motif replication; scaling; pattern sequencing	Ratio, similarity, tessellation, arithmetic sequences	Algebraic patterns; proportion; measurement
Logistics	Scheduling; route planning; budget allocation	Estimation, proportional distribution, constraint-based modeling	Number sense; problem solving; modeling

Theoretical Integration and Implications

Across domains, three structural features were evident:

a. Mathematics as functional necessity rather than decorative inclusion.
b. Integration across domains (geometry, algebraic reasoning, measurement, modeling).
c. Collective enactment rather than individual abstraction.

The findings support ethnomathematics by demonstrating that communities generate coherent mathematical systems through practice. They also extend existing research by showing that large-scale festivals function as integrative mathematical environments, not merely artifact-based examples. Rather than opposing formal mathematics, the evidence suggests continuity: embodied and procedural reasoning precede and parallel symbolic formalization.

CONCLUSION

This study examined the Sinulog Festival as a structured site of mathematical practice through an ethnomathematical lens. Addressing the limited documentation of large-scale cultural performances within mathematics education research, the findings demonstrate that mathematical reasoning operates integratively across choreography, material design, and logistical coordination. Multiple mathematical domains—including spatial transformation, proportional design, and quantitative modeling—were embedded as functional requirements within festival practice. These findings extend ethnomathematics scholarship beyond artifact-focused analyses by documenting how complex communal events operationalize multiple mathematical domains simultaneously. The study contributes empirical evidence from a Southeast Asian context. The results support the position that mathematical understanding is socially situated while remaining structurally rigorous. Cultural grounding does not dilute disciplinary integrity; rather, it reveals how formal mathematical domains are enacted in lived environments. Future research may explore comparative festival contexts or examine the instructional impact of integrating such environments into formal curricula.

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