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Cultural heritage as a mathematical context: Interpretation of set theory in spatial layout of Prambanan temple

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Abstract

Mathematics is often perceived as culturally neutral and detached from its social and historical foundations, leading to the neglect of cultural heritage rich in mathematical ideas. This study investigates how the concept of sets is reflected in the spatial layout of the Prambanan Temple Complex through an ethnomathematics perspective. By uncovering these embedded structures, the research demonstrates the potential of cultural heritage as a meaningful context for mathematics education, promoting both conceptual understanding and appreciation of cultural identity. Adopting an ethnomathematics perspective, this study employs ethnographic methods to analyze the spatial layout of the 9th-century Prambanan Temple. The investigation focuses on identifying mathematical principles within the temple's spatial classification system, particularly in relation to grouping, membership, and separation across the hierarchical zones of *Bhurloka*, *Bhuvarloka*, and *Swarloka*. The analysis reveals that ancient Javanese society implicitly can be interpreted as set-theoretical structures in the spatial layout of Prambanan Temple. The hierarchical spatial divisions demonstrate systematic applications of grouping, inclusion, and exclusion principles, reflecting mathematical thought embedded in cultural practices. These insights suggest that cultural artifacts such as temple architecture can be modeled through mathematical frameworks and provide authentic contexts for mathematics learning. This study contributes to the field of multicultural mathematics education by illustrating how cultural heritage can serve as a valuable resource in teaching through the Ethno-Realistic Mathematics Education approach. Situating mathematical concepts in culturally relevant contexts deepens conceptual understanding and strengthens cultural identity, offering practical implications for educators and curriculum developers seeking to embed multicultural perspectives in mathematics education.

Keywords:
Cultural heritage, Ethnography, Ethnomathematics, Prambanan temple, Set theory

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1. INTRODUCTION

For a long time, mathematics has been perceived as a universal, value-free, and culturally neutral discipline (Larvor, 2016). This perspective tends to detach mathematics from the social and cultural contexts in which it emerges (Bishop, 1991). However, the ethnomathematics approach challenges this notion by emphasizing that mathematics is not merely a collection of abstract symbols and formulas but rather a cultural construct that reflects the ways of thinking, behaving, and interpreting the world within specific communities (Wilder, 2014). From this perspective, every culture is believed to possess unique ways of applying mathematical concepts in daily life, whether consciously or unconsciously.

Indonesia, with its vast cultural and historical diversity, provides fertile ground for ethnomathematical exploration (Nur et al., 2023). Among its many cultural heritages, the Prambanan Temple Complex stands out as a site where spiritual, social, and mathematical knowledge converge (Singh, 2022). Constructed in the 9th century and designated a UNESCO World Heritage Site, Prambanan is not only the largest Hindu temple complex in Indonesia but also an exceptional example of architectural ingenuity (Degroot, 2009). Its spatial organization, rich with symbolic meaning, integrates mathematical concepts such as proportionality, symmetry, and orientation, closely linked to Hindu cosmology and the sociocultural order of ancient Javanese society (Campbell, 2018; Surpi, 2020).

Previous studies have examined the cultural and religious dimensions of Prambanan as well as its symbolic architecture (Orr, 2022; Srinivasan & Aithal, 2025) and focus on geometry pattern (Endaristi et al., 2023). However, limited research has explicitly analyzed the temple's design from an ethnomathematical perspective that highlights how mathematical reasoning is embedded in cultural practices. Most existing works either emphasize the historical and religious symbolism or focus narrowly on technical architectural aspects without systematically connecting them to mathematics education (Munthahana & Budiarto, 2020). This indicates a research gap in positioning Prambanan as a pedagogical source for contextual and culture-based mathematics learning.

The novelty of this study lies in its interdisciplinary approach, which combines ethnomathematics, cultural heritage studies, and mathematics education. Unlike earlier research that treated architecture and mathematics as separate domains, this study frames the Prambanan Temple Complex as a living repository of mathematical knowledge, embedded in cultural wisdom and relevant to modern educational contexts. In doing so, it not only uncovers hidden mathematical elements in the temple's layout and architecture but also reinterprets them as meaningful resources for mathematics learning.

The significance of this research is twofold. Academically, it contributes to the growing body of ethnomathematics by providing evidence that mathematical reasoning is culturally situated and manifested in Indonesia's architectural heritage. Practically, it offers an innovative model for integrating local wisdom into mathematics education, thereby fostering both contextual learning and cultural preservation (Mendrofa et al., 2024; Zuliana et al., 2023). Beyond education, this study supports efforts to strengthen cultural identity, promote cross-cultural understanding, and bridge modern scientific inquiry with traditional knowledge systems (Pisano, 2015; Rosa et al., 2016).

Finally, the purpose of this research is to explore and analyze the mathematical knowledge, namely set theory, embedded in the spatial layout of the Prambanan Temple Complex through an ethnomathematics perspective. By doing so, the study seeks to uncover the cultural dimensions of mathematics, highlight their relevance for contemporary education, and contribute to the preservation of Indonesia's intellectual and cultural heritage.

1.1. Ethnomathematics as a Cultural Framework

Ethnomathematics, a term first introduced by D'Ambrosio (1985), emphasizes the recognition of mathematical practices that emerge naturally within cultural groups as they engage in daily problem-solving, classification, measurement, and spatial organization. Unlike formal mathematics, which is typically codified through axioms and symbolic abstraction, ethnomathematics acknowledges that each culture develops its own valid mathematical systems that reflect local ways of knowing and interacting with the world (Borba, 1990; Wilder, 2014). This perspective challenges the conventional view of mathematics as universal and culturally neutral (Gerdes, 1994; Larvor, 2016), instead situating it within human experience, traditions, and values (Barton, 1996; Bishop, 1991). D'Ambrosio's framework also carries a humanistic dimension, aiming to dismantle epistemological hierarchies that privilege Western mathematics while marginalizing the intellectual contributions of non-Western cultures (D'Ambrosio, 2000).

In this regard, ethnomathematics aligns with broader educational discourses on multiculturalism and inclusivity. By recognizing mathematical practices embedded in cultural life, educators and researchers affirm intellectual diversity and resist the reduction of mathematics to an abstract, decontextualized discipline (Rosa & Orey, 2016). This theoretical lens therefore provides a foundation for understanding how mathematical reasoning is manifested in cultural artifacts such as architecture, crafts, rituals, and spatial arrangements. More importantly, it opens pathways for integrating cultural knowledge into contemporary mathematics education, thereby fostering meaningful learning experiences that are socially, historically, and philosophically situated.

1.2. Ethnomathematics in Cultural Heritage and Education

Empirical studies have increasingly demonstrated that cultural heritage sites serve as living repositories of mathematical knowledge. Architecture, in particular, often reflects systematic reasoning in proportion, symmetry, orientation, and classification (Dabbour, 2012). Research on ancient monuments across Asia, Africa, and Latin America has shown that spatial organization is rarely arbitrary but deeply connected to cosmological and social structures (Campbell, 2018; Hiscock, 2016; Singh, 2022). In Indonesia, temples such as Borobudur and Prambanan exemplify how mathematical thinking is intertwined with spiritual and cultural symbolism, demonstrating concepts such as hierarchical classification, geometric proportion, and axis-based symmetry (Degroot, 2009; Nur et al., 2023). However, most prior works, for instance Munthahana and Budiarto's (2020) reseach have emphasized either symbolic-religious interpretations or technical architectural analysis. It is leaving a gap in explicitly framing these structures within an ethnomathematical perspective.

From an educational standpoint, integrating ethnomathematics into teaching practice has been shown to enhance students' engagement, contextual understanding, and cultural pride. Approaches such as Ethno-Realistic Mathematics Education (Ethno-RME) encourage learners to rediscover mathematical ideas embedded in their cultural environment, thereby connecting abstract concepts to lived experiences (Prahmana, 2022). Furthermore, Rosa et al. (2016) and Zuliana et al. (2023) have also emphasized that such approaches foster inclusive and democratic learning environments, in line with global efforts to decolonize mathematics education. Within this framework, the Prambanan Temple Complex represents not only an architectural and historical masterpiece but also a pedagogical resource for contextual mathematics learning. By reinterpreting its spatial and geometric structures as mathematical constructs, educators can bridge traditional knowledge with modern curricula, strengthening both cultural preservation and mathematical literacy.

2. METHOD

This study employed an ethnographic approach to investigate the interrelationship between cultural heritage and mathematical concepts, with a particular focus on the spatial structure and architectural layout of the Prambanan Temple Complex. Ethnography, as a qualitative research method, seeks to provide an in-depth description of cultural practices and worldviews from the perspective of cultural actors (Whitehead, 2005). This approach is consistent with the principles of ethnomathematics, which aim to reveal mathematical reasoning embedded in cultural contexts and expressed through local practices.

The analysis centered on the grouping system and spatial organization of Prambanan Temple, which embodies the categorical thinking of ancient Javanese society (Degroot, 2009). Furthremore, Koentjaraningrat (2015) stated that ethnographic analysis can encompass seven cultural elements: language, technology, economy, social organization, knowledge systems, art, and religion. This study specifically focused on the knowledge system, examining how spatial classifications and hierarchical structures within the temple complex contain authentic mathematical concepts (Fuat et al., 2024).

Data collection was conducted over a four-week fieldwork period at the Prambanan temple complex. The study employed several complementary techniques. First, direct observations were carried out to document the spatial arrangements, grouping patterns, and architectural classifications of the temples. The observations were conducted through a combination of structured observation and spatial mapping, where the researchers systematically examined the temple layout, measured relative positions, and produced schematic sketches to represent structural relationships within the complex.

Second, semi-structured interviews were conducted with local cultural experts who were selected based on expertise in Javanese culture, temple history, and Hindu-Javanese cosmology. The interviews aimed to explore the philosophical and symbolic meanings embedded in the temple layout. The interviews were audio-recorded, transcribed verbatim, and then analyzed through thematic analysis to identify recurring interpretations related to cosmological and spatial concepts.

Third, documentation methods such as photographs, field notes, and schematic sketches were used to capture architectural details and support the observation data. Finally, a literature review of historical texts, archaeological reports, and studies on Hindu-Javanese cosmology was conducted to triangulate the field findings and provide a broader interpretive framework. Ethical considerations were maintained throughout the study. All participants were informed about the purpose of the research, and their voluntary consent was obtained prior to the interviews.

Data were analyzed using content analysis, with a particular emphasis on identifying classification systems that could be modeled through mathematical constructs. Specifically, the categorization of temple zones and their hierarchical relationships were interpreted in terms of sets and subsets, thereby connecting cultural practices to fundamental concepts in set theory. Table 1 illustrates the ethnographic research design, including guiding questions, points of inquiry, and the associated mathematical interpretation.

Table 1. Ethnographic research design

Research Question	Initial Focus	Cultural Context	Specific Activity	Mathematical Interpretation
Where to start?	Structures and symbols in the Prambanan zones	Hindu–Javanese cosmology	Observation of *Bhurloka*, *Bhuvarloka*, and *Swarloka*	Identification of hierarchical sets
How to observe?	Shapes, locations, and distribution of temples	Sacred architecture	Analysis of spatial grouping	Classification by set membership
What was discovered?	Hierarchical and exclusive classification	Local mathematical thought	Identification of temple groupings	Modelling with sets and subsets
What does it mean?	Systematic thinking in temple organization	Ethnomathematics and cognitive anthropology	Reflection on cultural reasoning	Connection between culture and mathematical structures

Through this methodological framework, Prambanan Temple is interpreted as a representation of ethnomathematics, where mathematical ideas are expressed not only in formal symbols but also in cultural, spatial, and spiritual systems. This perspective reinforces D'Ambrosio (1999) assertion that every culture possesses authentic mathematical systems, even if they are not explicitly articulated through axioms or formulas (Wilder, 2014). Accordingly, the findings from this study have the potential to enrich mathematics education by making it more inclusive, contextual, and reflective of students' cultural backgrounds.

3. RESULTS AND DISCUSSION

3.1. Results

3.1.1. Cosmological Grouping in the Spatial Layout of Prambanan Temple

This research found that the spatial organization of the Prambanan Temple Complex is built on a three-zone classification system that is consistently applied and empirically observable. Based on direct field observations, spatial mapping, and interviews with cultural informants, the division of space into *Bhurloka*, *Bhuvarloka*, and *Swarloka* zones proved to be not only symbolic, but also emphasized through elevation differences, levels of spatial enclosure, and access arrangements between zones. As shown in Figure 1, movement from the outermost area towards the main temple requires visitors to pass through the spatial boundaries sequentially, indicating that the zones function as spatial categories that are enforced in real terms.

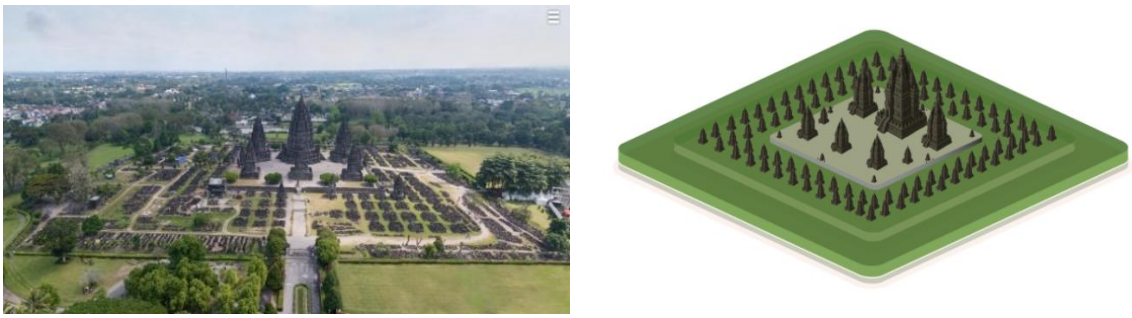

Figure 1. The spatial layout of Prambanan temple complex

Observations also show that each temple structure is only in one particular zone, with no structure crossing two zones at once. All structures can be clearly classified into one of the zones. This finding is reinforced by the explanation of a temple guide in an interview as follows *(H. Saptana, Personal Communication, May 15, 2025)*:

> *"Each temple is placed according to its level of sacredness. The main temples are located in the innermost courtyard, while the smaller temples are arranged in the middle and outer courtyards. No temple crosses these boundaries because the spatial order reflects the sacred structure of the universe."*

Bhurloka represents the realm of worldly life, still bound by human desires. In the temple complex, this zone corresponds to the outermost area, symbolizing the initial stage of spiritual pursuit. Furthermore, *Bhuvarloka* signifies the transitional stage in which humans begin to distance themselves from material attachments and move toward spiritual practices. Architecturally, this stage is represented by the *Perwara* temples 244 small structures arranged around the core zone reflecting collective human effort in devotion. Finally, *Swarloka* is the innermost and most sacred realm, the dwelling place of deities, representing the culmination of spiritual enlightenment. This zone contains Guardian temples (*Patok*, *Apit*, and *Kelir*), Vehicle temples (*Nandi*, *Angsa*, and *Garuda*), and the three central Trimurti temples dedicated to *Shiva*, *Vishnu*, and *Brahma*. The illustration of the three zones' cosmos *Bhurloka*, *Bhuvarloka*, and *Swarloka* can be seen in Figure 2.

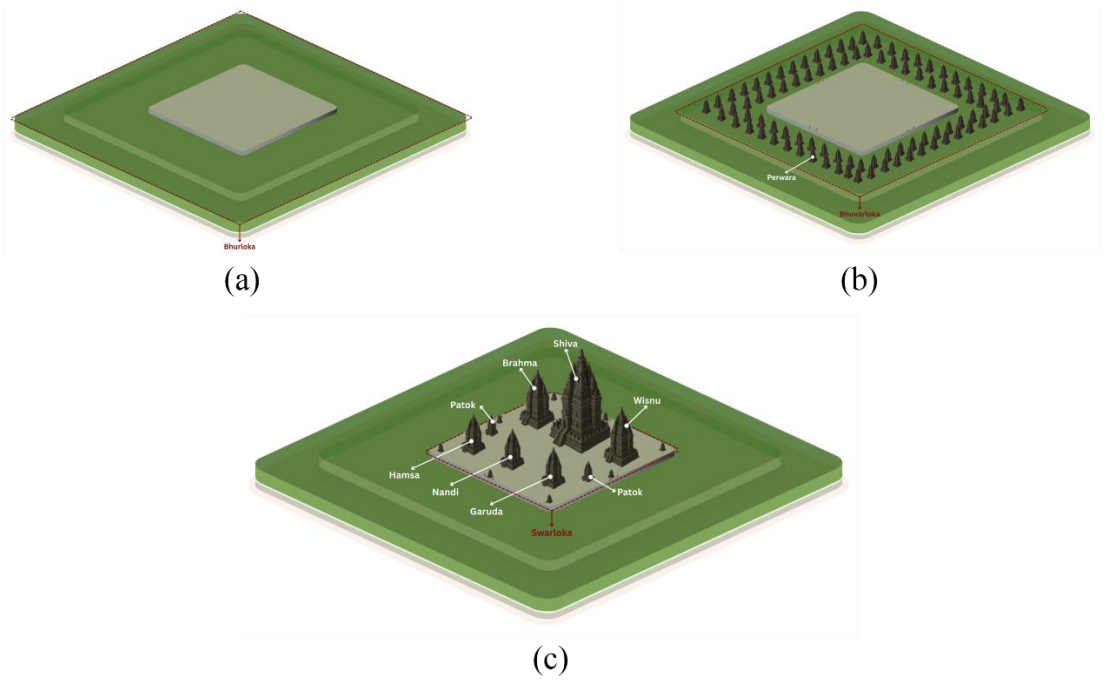

Figure 2. The three zones' cosmos illustration: (a) *Bhurloka*, (b) *Bhuvarloka*, and (c) *Swarloka*

Furthermore, this study found that *Bhurloka*, as the outermost zone shown in Figure 2(a), does not contain any temple buildings that function as ritual units. Field notes consistently recorded this zone as an open space that functions as a transition and circulation area. In contrast, *Bhuvarloka*, as shown in Figure 2(b), is characterized by the presence of 244 *Perwara* temples arranged in a regular and repetitive pattern around the core zone. A cultural informant explained the meaning of this arrangement as follows *(H. Saptana, Personal Communication, May 15, 2025)*:

> *"Perwara temples are many because they symbolize human beings who have begun to know God and are spiritual, in contrast to the main temple which has only a few temples because it symbolizes humans who have reached a spiritual peak, are one with God, and no longer think about the world."*

Meanwhile, *Swarloka*, shown in Figure 2(c), is the deepest and most enclosed zone, with the highest elevation and most restricted access. This zone contains the guardian temples (*Patok*, *Apit*, and *Kelir*), the vehicle temples (*Nandi*, *Swan*, and *Garuda*), and the three main Trimurti temples dedicated to *Shiva*, *Vishnu*, and *Brahma*. Observation records show that the restriction of access to this zone reinforces its position as the highest level of sacredness in the temple's spatial structure.

Conceptually, *Bhurloka* represents the realm of earthly life still bound by human desires, *Bhuvarloka* marks the transitional stage towards spiritual practices, and *Swarloka* symbolizes the pinnacle of spiritual achievement as the abode of the gods. A cosmological representation of the three zones of *Bhurloka*, *Bhuvarloka* and *Swarloka* is shown in Figure 2.

This classification demonstrates that spatial organization in Prambanan was not arbitrary but reflected a coherent system of meaning that connected cosmology, spirituality,

and social order. Every structure held symbolic value and specific hierarchical significance, illustrating the ability of Javanese society to construct a classification system that integrates both physical and metaphysical dimensions.

Overall, the findings of this study indicate that the spatial organization of the Prambanan Temple Complex reflects a coherent, hierarchical, and consistently applied classification system that integrates spatial boundaries, differences in the number of buildings, and access arrangements. This system reveals structured reasoning linking cosmology, spirituality, and social order, and provides a strong ethnographic empirical foundation for subsequent mathematical analysis using a set theory framework.

Bhurloka represents the realm of worldly life, still bound by human desires. In the temple complex, this zone corresponds to the outermost area, symbolizing the initial stage of spiritual pursuit. Furthermore, *Bhuvarloka* signifies the transitional stage in which humans begin to distance themselves from material attachments and move toward spiritual practices. Architecturally, this stage is represented by the *Perwara* temples 244 small structures arranged around the core zone reflecting collective human effort in devotion. Finally, *Swarloka* is the innermost and most sacred realm, the dwelling place of deities, representing the culmination of spiritual enlightenment. This zone contains Guardian temples (*Patok*, *Apit*, and *Kelir*), Vehicle temples (*Nandi*, *Angsa*, and *Garuda*), and the three central Trimurti temples dedicated to *Shiva*, *Vishnu*, and *Brahma*.

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3.1.2. Mathematical Interpretation: Set-Theory Modeling

The categorical thinking reflected in the temple's spatial arrangement aligns closely with the foundational principles of modern set theory. The temples of Prambanan can be considered elements of a universal set, expressed as:

S={Perwara temples, Pathok temple, Apit temple, Kelir temple, Wahana temples, Main temples}

From this universal set, three principal subsets emerge, corresponding to the cosmological zones:

(1) *Bhurloka* (B_1): an empty space representing the beginning of human existence presented in Figure 2(a). The *Bhurloka* zone can be mathematically modeled as a subset with empty sets as its members.

$$B_1 = \emptyset$$

(2) *Bhuvarloka* (B_2): the transitional realm, symbolized by the 244 *Perwara* temples (Guardian temple) as illustrated in Figure 2(b). The *Bhuvarloka* zone can be mathematically modeled as a subset with members of the set being the small temples.

$$B_2 = \{Perwara\ Temples\}$$

(3) *Swarloka* (B_3): the sacred realm, composed of guardian, vehicle, and Trimurti temples as shown in Figure 2(c). The deepest zone symbolizes spiritual enlightenment and union with the almighty power.

$$B_3 = \{Guardian\ Temple, Vehicle\ Temple, Main\ Temple\}$$
$$Guardian\ Temple = \{Patok\ Temple, Apit\ Temple, Kelir\ Temple\}$$
$$Vehicle\ Temple = \{Nandi\ Temple, Angsa\ Temple, Garuda\ Temple\}$$
$$Main\ Temple = \{Brahma\ Temple, Shiva\ Temple, Vishnu\ Temple\}$$

The relationship between sets in modeling the Prambanan Temple Complex shows the existence of disjoint sets and hierarchically arranged classifications. By defining S as the universe set that represents all temple buildings that become the unit of analysis, and B_1, B_2, B_3 as the set of buildings in the *Bhurloka*, *Bhuvarloka*, and *Swarloka* zones, respectively, the exclusivity relationship between zones can be expressed as follows:

$$B_1 \cap B_2 = B_1 \cap B_3 = B_2 \cap B_3 = \emptyset$$

This relation shows that each temple building is only a member of one set of zones and is not on the intersection of two zones at once, so the three sets are pairwise disjoint sets. At the same time, the union of the three sets re-forms the universe set:

$$B_1 \cup B_2 \cup B_3 = S$$

This structure reflects a partition of the universe set, where each element of the S belongs to exactly one subset without overlapping (Foreman, 2009). In addition, the characteristics of each zone can also be analyzed through the concept of cardinality, for example the difference in the number of elements between B_2 (244 ancillary temples) and B_3 (main and supporting temples), which shows that the two sets are not cardinally equivalent even though they are both subsets of the S.

Furthermore, the hierarchical relation between zones allows the exploration of other set theory concepts, such as subsets, complements, as well as set differences, for example when a particular building is defined as a member of *Swarloka* but not *Bhuvarloka*. Thus, although not formalized symbolically in its historical context, the spatial and spiritual organization of Prambanan Temple demonstrates the application of core principles of set theory-including classification, partitioning, membership relations, and abstract reasoning-that are in line with modern mathematical frameworks (Foreman, 2009).

3.2. Discussion

3.2.1. Mathematical Structures in the Prambanan Temple Complex

The findings of this study reaffirm the importance of positioning mathematics as a cultural construct that is not exclusively rooted in Western traditions or confined to the boundaries of formal schooling (D'Ambrosio, 2000). This perspective resonates strongly with the theoretical framework introduced by D'Ambrosio (1985), who pioneered the concept of ethnomathematics to acknowledge and appreciate the mathematical practices that naturally emerge within diverse local cultures across the world.

According to D'Ambrosio (1985), ethnomathematics refers to the ways in which cultural groups engage in activities such as counting, measuring, classifying, organizing space, and solving everyday problems. Each cultural system possesses its own legitimate mathematical structures, even when they are not explicitly expressed in axiomatic or symbolic form as in Western mathematics (D'Ambrosio, 2000). This perspective also carries a humanistic dimension by challenging epistemological hierarchies and recognizing the contributions of non-Western cultures to the broader history of mathematical thought.

In the context of this study, the spatial organization of the Prambanan Temple complex exemplifies ethnomathematical practices of the 9th-century Javanese society. The division of the complex into three cosmological zones *Bhurloka*, *Bhuvarloka*, and *Swarloka* can be modeled using set theory. Let

$$S = \{B, B_u, S_w\}$$

denote the universal set representing the entire temple complex, where B is the set of temples in *Bhurloka*, B_u is the set of temples in *Bhuvarloka*, and B_w is the set of temples in *Swarloka*. Each subset B, B_u, $S_w \subseteq S$ is disjoint, and their union reconstructs the whole complex:

$$B \cup B_u \cup S_w = S$$
$$B \cap B_u = B \cap S_w = B_u \cap S_w = \emptyset$$

Furthermore, the hierarchical structure implies an ordering relation such that

$$B \prec B_u \prec S_w$$

which reflects both spatial elevation and spiritual hierarchy. Within each subset, additional classifications can be made (e.g., the main shrine versus peripheral shrines), yielding nested subsets analogous to subgroup structures in algebra.

This interpretation aligns with D'Ambrosio's assertion that mathematics is a socio-cultural practice that arises from humanity's need to structure experience, interact with the environment, and conceptualize metaphysical realities (D'Ambrosio, 1999). The Prambanan Temple is therefore not merely an architectural or aesthetic achievement, but also an epistemic system that integrates logic, order, and abstraction with spiritual, philosophical, and social values (Bailly & Longo, 2011). Mathematics in this context is thus not culturally neutral but deeply embedded with meaning, identity, and worldview.

The implications for mathematics education are profound. If mathematics is presented only as formal abstraction, detached from cultural context, its relevance and meaning for learners may be diminished (Rosa & Orey, 2016). Conversely, approaches such as Ethno-RME encourage students to rediscover mathematical structures within their own culture (Prahmana, 2022). For example, Prambanan's classification system can be translated into classroom tasks where students model cultural artifacts using sets, subsets, and hierarchical relations. Such practices not only foster deep conceptual understanding but also strengthen cultural identity and appreciation, consistent with the principles of meaningful and inclusive learning (Prahmana & Istiandaru, 2021).

In this way, the Prambanan Temple complex serves as a cultural-mathematical narrative, reflecting the intellectual traditions of Javanese society and providing a rich resource

for contemporary mathematics education. This study therefore reinforces D'Ambrosio's (1985, 1999, 2000) vision of ethnomathematics as a foundation for inclusive, democratic education, while also demonstrating that mathematical reasoning can be rigorously modeled through set theory (Prahmana & Istiandaru, 2021) and geometry (Prahmana & D'Ambrosio, 2020) yet remains inseparably bound to culture, spirituality, and lived human experience.

3.2.2. The Structure of Prambanan Temple as a Promising Context for Mathematics Learning

The structural logic embedded in Prambanan Temple has significant pedagogical potential. Within the framework of Ethno-RME, the temple's classification system can serve as a meaningful cultural context for teaching set theory. By engaging students in activities such as constructing replicas of the temple complex, grouping miniature temples by zone, and representing these groups using set notation, teachers can bridge cultural heritage and abstract mathematical concepts.

A proposed learning trajectory includes:

(1) Concrete Situations - Introducing the Prambanan Temple's Structure

Students are engaged in a collaborative activity to construct a simple replica of the Prambanan Temple complex using materials such as cardboard, clay, or wooden blocks. Throughout this process, teachers contextualize the cultural and philosophical significance of the temple's design, with particular attention to the three spiritual zones: *Bhurloka*, *Bhuvarloka*, and *Swarloka*. Historical narratives and elements of Hindu-Javanese cosmology are also introduced to explain the tiered arrangement of the temples and the symbolic meaning of their varying numbers and positions. This activity not only fosters conceptual understanding but also promotes joyful, mindful learning while strengthening students' emotional connection to cultural heritage.

(2) Model of - Classifying and Grouping Replicas of Prambanan Temple

After completing the replicas, students were instructed to classify the miniature temples according to their respective spiritual zones. For instance, they placed 244 *Perwara* temples in the *Bhuvarloka* zone and positioned the *Wahana*, *Kelir*, *Apit*, *Patok*, and *Trimurti* temples (*Shiva*, *Brahma*, and *Vishnu*) in the *Swarloka* zone. Through this activity, students began to construct a conceptual framework of classification by distinguishing temples based on number, size, function, and spatial location. Although formal mathematical terminology was not yet employed, students developed a cognitive structure analogous to the concept of sets and became increasingly aware of the spatial patterns inherent in the architectural design.

(3) Model for - Developing Mathematical Representations

The next stage involves transforming the cultural model into a formal mathematical representation. Students record the temples as elements of a set, organize subsets according to spiritual zones, and investigate the relationships between sets through set operations. At this point, set theory is not merely introduced as an abstract concept but as a representational model of tangible cultural structures. This process enables students to

construct a meaningful understanding of mathematical ideas within a context they have actively developed.

(4) Formal Knowledge - Generalization, Reflection, and Application of Concepts

The final stage positions students to reflect on and generalize the knowledge they have constructed. Teachers facilitate discussions on how the principles of classification and hierarchical structures embodied in the Prambanan Temple reflect the systematic thinking of past societies. Students are further encouraged to apply set concepts to diverse contexts such as the classification of flora and fauna, professional categories, or organizational systems while practicing formal symbolization and problem-solving using set notation. Through this process, students come to recognize that mathematics is not developed in isolation but emerges as a form of knowledge rooted in human experience, cultural beliefs, and social structures. This reflective awareness strengthens the mindful dimension of learning. Consequently, mathematics education becomes not merely the transmission of abstract concepts, but a process of constructing holistic meaning. Beyond understanding set theory, students cultivate curiosity, cultural appreciation, and the capacity for reflective and cross-disciplinary thinking. This model aligns with the principles of deep learning curricula and holds significant potential for integration into contextual mathematics education that meaningfully incorporates local culture as a source of learning.

This trajectory illustrates that mathematics is not an abstract construct detached from human experience, but a cultural practice that evolves within social, religious, and spatial systems. In this sense, Prambanan Temple serves not only as a cultural heritage site but also as a living example of ethnomathematics that can foster deep, contextual, and reflective mathematics learning.

3.2.3. Theoretical and Practical Research Impact in Multicultural Mathematics Education

This research strengthens the view that mathematics should be understood not only as an abstract and universal system but also as a culturally situated form of reasoning that reflects the intellectual traditions of diverse societies (Barton, 1996; Bishop, 1991). By modeling the spatial and hierarchical structure of the Prambanan Temple Complex through set theory, the study demonstrates that key mathematical ideas such as grouping, subsets, cardinality, disjoint sets, and hierarchical classification are embedded within Javanese cosmology. This finding extends the ethnomathematics framework proposed by D'Ambrosio (1985) by providing empirically grounded evidence that mathematical reasoning exists as a lived cultural practice manifested in architectural organization and spiritual worldviews, rather than solely as a formal axiomatic system.

From a pedagogical perspective, the findings offer concrete and actionable applications within the Ethno-Realistic Mathematics Education (Ethno-RME) approach (Prahmana, 2022). For example, based on the Prambanan zoning system, teachers can design classroom tasks in which students construct Venn diagrams representing *Bhurloka*, *Bhuvarloka*, and *Swarloka* as mutually disjoint subsets within a universal set of temple buildings. Students may be asked to identify set elements (individual temples), compare

cardinalities (e.g., *Perwara* temples versus main temples), and determine complements (e.g., temples not belonging to *Swarloka*). Such tasks directly reflect the empirical findings of this study and support a progression from contextual reasoning to formal set notation.

Additionally, teachers can employ context-based modeling activities, such as mapping the temple layout onto diagrams or digital slides, to help students visualize hierarchical classification and spatial reasoning before transitioning to abstract representations. These activities align with deep learning principles by encouraging exploration, reflection, and meaning-making rather than rote symbol manipulation.

Despite its potential, the integration of ethnomathematics into classroom practice presents several challenges. Teachers may face constraints related to limited familiarity with cultural-historical contexts, time allocation within the curriculum, or access to suitable instructional media. To address these challenges, the Prambanan context should be used selectively and strategically, focusing on set theory topics explicitly prescribed in Grade VII curricula, such as universal sets, subsets, cardinality, and disjoint sets. More abstract operations (e.g., complement or difference of sets) can be introduced through contextual extension beyond the temple example.

In terms of curriculum alignment, this approach complements competency-based and deep learning-oriented curricula by linking mathematical abstraction with local cultural knowledge. Rather than replacing existing content, the Prambanan Temple context functions as an entry point that supports conceptual understanding while remaining consistent with curricular standards and learning objectives.

Beyond classroom implementation, this research contributes to the broader goals of multicultural and inclusive mathematics education. By recognizing that mathematical reasoning is not confined to Western traditions, the study challenges epistemological hierarchies and promotes respect for intellectual diversity (D'Ambrosio, 2000). Integrating cultural narratives such as the Prambanan Temple into mathematics education can strengthen students' cultural identity, foster appreciation for local wisdom, and position mathematics as a human endeavor rooted in social and cultural experience (Bailly & Longo, 2011; Borba, 1990; Campbell, 2018). In this way, the study provides a realistic pathway toward culturally responsive mathematics education that is both theoretically grounded and pedagogically feasible.

4. CONCLUSION

This study demonstrates that the Prambanan Temple Complex can be interpreted as a concrete representation of set theory thinking, wherein the spatial classification systems of *Bhurloka*, *Bhuvarloka*, and *Swarloka* constitute mathematically consistent partitions through the concepts of universal set, subset, cardinality, and mutually exclusive sets. The findings confirm that mathematical reasoning within the Prambanan context is not merely symbolic or ornamental but reflects a logical and systematic structure aligned with the fundamental principles of modern mathematics.

Methodologically, this research contributes by demonstrating that the ethnomathematical approach can be rigorously applied to model cultural artifacts using a formal mathematical-theoretical framework, particularly set theory. The findings open

avenues for subsequent studies to conduct focused and feasible research on the mathematical modeling of other cultural artifacts without compromising conceptual precision. Furthermore, for educators and curriculum developers, this study conveys a clear pedagogical implication: local cultural contexts such as the Prambanan Temple can be directly and structurally integrated into the teaching of Grade VII set theory, particularly the concepts of the universal set, subset, cardinality, and mutually exclusive classification. By grounding instruction in real and meaningful cultural structures, mathematics learning becomes not only more contextualized and engaging but also helps students recognize that mathematics emerges from human experience, cultural expression, and social organization. Therefore, this study affirms that ethnomathematics transcends cultural preservation; it serves as a viable pedagogical and epistemological approach to bridging mathematical abstraction with cultural experience. Consequently, the Prambanan Temple should be viewed not merely as a historical monument but also as a living repository of mathematical knowledge that holds relevance for contemporary and future mathematics education.

Despite these contributions, the present study acknowledges several limitations. First, the analysis primarily focused on classification structures within the temple complex, leaving other mathematical dimensions—such as numerical sequences or measurement systems—beyond its scope. Second, the ethnographic data were limited to a restricted number of observations and interviews, which may not fully capture the diversity of local interpretations and symbolic meanings embedded within the site. Third, this study was conducted within a specific cultural and historical context, which may constrain the generalizability of its findings to other cultural or architectural traditions.

Building on these findings, which suggest that the spatial structure of the Prambanan Temple Complex can be consistently modeled through key set theory concepts (partition, cardinality, and membership relations), subsequent research should prioritize expanding ethnomathematical exploration into other mathematical domains closely related to classification structures—such as simple relations, functions, hierarchical sequences, and numerical representations in ritual and architectural systems. This focus is methodologically feasible, given its reliance on spatial and symbolic data similar to that used in the present study, and therefore amenable to comparable ethnographic and mathematical modeling methods.

A second direction involves conducting a limited comparative analysis between Prambanan and other Javanese temples (e.g., Borobudur or Panataran) to examine whether the identified set partitioning patterns and spatial hierarchies are distinctive to Prambanan or represent more general cosmological patterns characteristic of Hindu-Buddhist traditions in the Indonesian archipelago. Such a focused comparative study is methodologically more realistic than a broad cross-cultural comparison and allows for richer, contextually grounded analysis.

Third, in terms of educational implementation, further research should examine the empirical feasibility of using the Prambanan context in teaching Grade VII set theory through small-scale classroom experiments or design-based research. This should initially focus on concepts directly supported by the present findings such as the universal set, subset, cardinality, and mutually exclusive sets before extending to more abstract set operations. Such

an approach ensures that the integration of ethnomathematics remains scalable, contextually relevant, and aligned with the national curriculum.

In sum, future research directions should not only extend the conceptual discourse of ethnomathematics but also fortify the link between theoretical insights, cultural context, and practical educational applications. By doing so, they contribute to the preservation of cultural heritage as a dynamic source of meaningful mathematical knowledge within a multicultural society.

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Declarations

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