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GEOMETRIC STRUCTURE ANALYSIS OF MBAH BUYUT KI TUAN TOMB GATE AS A CONTEXTUAL LEARNING RESOURCE FOR DECOMPOSITION OF THREE-DIMENSIONAL SHAPES IN ELEMENTARY SCHOOL STUDENTS

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Abstract

This research aims to analyze the potential of the geometric structure of the Mbah Buyut Ki Tuan Tomb gate in Karanglo Village as a contextual learning resource for three-dimensional shapes material, specifically decomposition skills and critical thinking enhancement in elementary school students. The study is motivated by the underutilization of local wisdom as an ethnopedagogical basis in mathematics learning, despite local traditions and cultural artifacts possessing strong visual-spatial values. The research employs a descriptive qualitative approach through direct observation, visual documentation, and interviews with local informants. Data were analyzed using reduction, categorization, and conclusion-drawing techniques. Results indicate that the tomb gate contains clearly identifiable three-dimensional shape elements recognizable to students, such as rectangular prisms in pillars and foundations, and cubes in upper ornamental sections. The gate structure can be decomposed into combinations of rectangular prisms and cubes, which can then be reconstructed as composite three-dimensional shapes. The analysis also reveals that utilizing this cultural object has potential to enhance the connection between mathematical concepts and real contexts, strengthen spatial visualization abilities, and promote critical thinking skills. Beyond mathematical values, relevant ethnopedagogical values were discovered, including respect for ancestors, mutual cooperation, and local cultural identity. The research concludes that the Mbah Buyut Ki Tuan Tomb gate is suitable as an ethnopedagogy-based contextual learning resource and can be integrated into digital media development, including Scratch, to enrich students' learning experiences. These findings provide a preliminary basis for developing locally culture-based mathematics learning media that is pedagogically valid and socially meaningful.

Keywords: ethnopedagogy, three-dimensional shapes, decomposition, critical thinking, local wisdom

Abstrak

Penelitian ini bertujuan untuk menganalisis potensi struktur geometris gerbang Makam Mbah Buyut Ki Tuan di Desa Karanglo sebagai sumber belajar kontekstual untuk materi bentuk tiga dimensi, khususnya keterampilan dekomposisi dan peningkatan berpikir kritis pada siswa sekolah dasar. Studi ini didorong oleh kurang dimanfaatkannya kearifan lokal sebagai dasar etnopedagogis dalam pembelajaran matematika, meskipun tradisi lokal dan artefak budaya memiliki nilai visual-spasial yang kuat. Penelitian menggunakan pendekatan kualitatif deskriptif melalui observasi langsung, dokumentasi visual, dan wawancara dengan informan lokal. Data dianalisis menggunakan teknik reduksi, kategorisasi, dan penarikan kesimpulan. Hasil menunjukkan bahwa gerbang makam mengandung elemen bentuk tiga dimensi yang jelas dapat dikenali oleh siswa, seperti balok persegi panjang pada tiang dan pondasi, serta kubus di bagian ornamen atas. Struktur gerbang dapat diurai menjadi kombinasi balok persegi panjang dan kubus, yang kemudian dapat direkonstruksi menjadi komposisi bangun ruang. Analisis juga mengungkapkan bahwa memanfaatkan objek budaya ini berpotensi meningkatkan keterkaitan antara konsep matematika dan konteks nyata, memperkuat kemampuan visualisasi spasial, serta mendorong keterampilan berpikir kritis. Di luar nilai matematika, ditemukan pula nilai etnopedagogis yang relevan, termasuk penghormatan terhadap leluhur, gotong royong, dan identitas budaya lokal. Penelitian ini menyimpulkan bahwa gerbang Makam Mbah Buyut Ki Tuan cocok sebagai sumber belajar kontekstual berbasis

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etnopedagogi dan dapat diintegrasikan ke dalam pengembangan media digital, termasuk Scratch, untuk memperkaya pengalaman belajar siswa. Temuan ini memberikan landasan awal untuk mengembangkan media pembelajaran matematika berbasis budaya lokal yang valid secara pedagogis dan bermakna secara sosial.

Kata kunci: etnopedagogi, bangun ruang, dekomposisi, berpikir kritis, kearifan lokal

INTRODUCTION

The integration of local wisdom into mathematics education has gained increasing attention as educators seek to make learning more meaningful and culturally relevant for students. Recent studies demonstrate that ethnomathematics-based approaches significantly improve students' conceptual understanding and motivation in geometry learning (Larasati et al., 2025; Zainovi et al., 2025). The incorporation of cultural artifacts as learning resources bridges the gap between abstract mathematical concepts and tangible real-world applications, particularly in elementary education where concrete experiences form the foundation for mathematical reasoning. However, despite the recognition of ethnopedagogy's potential, systematic documentation and analysis of local cultural structures for geometry instruction remain limited. This gap is particularly evident in rural areas where rich cultural traditions exist but are rarely leveraged as pedagogical resources.

Three-dimensional geometry presents unique challenges for elementary students, requiring the development of spatial visualization skills and the ability to decompose complex shapes into simpler components. Decomposition, defined as the ability to break down complex problems or structures into manageable parts, has been identified as a fundamental aspect of computational thinking and problem-solving in mathematics (Adiyastuti et al., 2024). Research indicates that students who successfully master decomposition skills demonstrate superior performance in solving complex geometric problems and exhibit enhanced critical thinking abilities. Furthermore, the connection between decomposition skills and spatial reasoning is crucial for understanding composite three-dimensional shapes, where students must identify constituent elements and their relationships. Nevertheless, traditional mathematics instruction often relies on abstract representations that fail to engage students' prior knowledge and cultural experiences.

The Manganan tradition at Mbah Buyut Ki Tuan's tomb in Karanglo Village, Tuban Regency, represents a rich cultural heritage that combines religious, social, and educational values. This annual commemoration, held every Dzulhijjah on Kamis Pon, serves not only as a spiritual gathering but also as a manifestation of community solidarity and intergenerational knowledge transfer. The tomb's gate structure, constructed with geometric precision, embodies architectural elements that align with elementary mathematics curriculum standards for three-dimensional shapes. The gate's design incorporates rectangular prisms in its pillars and foundation, complemented by cubic ornaments at the apex, creating a composite structure ideal for decomposition analysis. This architectural feature provides an authentic context for students to explore geometric concepts while simultaneously learning about their cultural heritage and developing appreciation for local wisdom.

Current trends in mathematics education emphasize the importance of contextual and culturally responsive teaching approaches that recognize students' diverse backgrounds and experiences. Ethnopedagogy-based learning has been shown to increase not only mathematical achievement but also students' cultural literacy and sense of identity (Nurtriana & Nuryadi, 2025; Wulandari et al., 2024). The integration of digital technologies, particularly programming environments like Scratch, with ethnomathematical content creates powerful learning opportunities that combine computational thinking with cultural appreciation. Studies on Scratch implementation in geometry education demonstrate significant improvements in students' motivation, collaborative skills, and critical thinking abilities (Jiang & Li, 2021; Molina-Ayuso et al., 2023). However, the synthesis of ethnopedagogical approaches with digital tools for teaching decomposition in three-dimensional geometry remains an underexplored area requiring further investigation.

The potential of augmented reality and digital media to enhance ethnomathematics learning has been documented in recent literature, showing promising results in improving spatial abilities and student engagement. Research on AR-based ethnomathematics learning media indicates significant effectiveness in developing spatial skills and increasing student involvement in 3D geometry lessons (Gustina et al., 2025; Maharbid et al., 2025). Digital comics and interactive e-modules incorporating local cultural elements have proven effective in enhancing conceptual understanding and mathematical connections (Prabasari et al., 2025; Rahayu et al., 2025). These technological integrations create multimodal learning experiences that appeal to diverse learning styles while preserving cultural authenticity. Nevertheless, the development of such resources requires careful analysis of the cultural artifacts' geometric properties and their pedagogical affordances for specific mathematical concepts.

This research addresses the need for systematic analysis of cultural structures as geometry learning resources by examining the Mbah Buyut Ki Tuan Tomb gate's geometric composition and its potential for teaching decomposition skills. The study contributes to the growing body of literature on ethnopedagogy in mathematics education by providing detailed documentation of a culturally significant architectural structure and its mathematical properties. By analyzing how this cultural artifact can be utilized to develop students' decomposition abilities and critical thinking in three-dimensional geometry, this research offers practical insights for educators seeking to implement culturally responsive mathematics instruction. The findings will inform the development of ethnopedagogy-based learning media, particularly digital tools like Scratch, that authentically integrate local wisdom into elementary mathematics curriculum while supporting computational thinking and spatial reasoning development.

Ethnomathematics research in Indonesia has shown significant development, particularly through studies that explore cultural activities and local crafts as sources of mathematics learning. Studies such as Ethnomathematics in the Activities and Handicrafts of the Dayak Jangkang Community (Ellissi & Liliana, 2023) provide an important contribution by identifying mathematical concepts embedded in traditional activities. However, this research places greater emphasis on identifying mathematical elements rather than linking them directly to specific spatial geometry skills in students. Another study, Introduction to Plane and Solid Geometry Through the Historical Building of Tjong A Fie (Zega & Naprila, 2025), demonstrates that historical buildings can serve as a relevant learning context. Nevertheless, its focus remains limited to the introduction of geometric forms and has not yet addressed more specific analytical abilities such as the decomposition of three-dimensional shapes.

Meanwhile, the development of learning technology through the Augmented Reality Application for Elementary School Geometry of Plane and Solid Figures (Putra et al., 2023) has shown that digital media can enhance students' understanding of geometry. However, the study does not integrate local cultural contexts, thereby losing the contextual dimension that is the strength of ethnomathematics. In contrast, the international study by Conceição and Rodrigues (2022) on first grade students' decomposition of 3D shapes provides a deep understanding of young learners' decomposition abilities, but it does not utilize cultural artifacts as objects of exploration and does not focus on the Indonesian context.

From these comparisons, a significant research gap becomes apparent: no existing studies have combined the geometric structural analysis of local cultural artifacts with the development of students' decomposition of three-dimensional shapes, especially at the elementary school level. Furthermore, the integration of ethnomathematics with interactive technology has not been optimally utilized to support contextual learning of spatial geometry. Therefore, research that examines local cultural artifacts—such as tomb gates, traditional houses, or historical structures—as media for developing students' abilities in three-dimensional shape decomposition is urgently needed to fill this gap and contribute new insights to the Indonesian mathematics education literature.

METHODS

This research employed a descriptive qualitative approach to analyze the geometric structure of the Mbah Buyut Ki Tuan Tomb gate and its potential as a learning resource for decomposition of three-dimensional shapes. The study was conducted in Karang Agung hamlet, Karanglo Village, Kerek Sub-district, Tuban Regency, East Java, Indonesia, during the Manganan tradition observation in Dzulhijjah. Data collection utilized multiple methods including direct observation of the gate structure, photographic documentation from various angles, measurement of architectural dimensions, and semi-structured interviews with key informants. The primary informant was Mbah Modin Wahap Kusmiyarto, S.Pd.I, who serves as the tomb caretaker and possesses extensive knowledge of the site's history and cultural significance. Mbah Modin is the only religious and community figure who truly understands the origins of the Manganan Tradition in the Haul Mbah Buyut Ki Tuan. He knows the story from generation to generation, passed down from his parents, who were also respected community figures in the past. Due to the limited number of sources in Karanglo Village, all information regarding the origins and meaning behind the Commemoration of Mbah Buyut Ki Tuan was obtained in detail from him.

The research instruments consisted of observation protocols for geometric structure analysis, digital cameras for visual documentation, measuring tools for dimensional recording, and interview guides for gathering cultural-historical context. The observation protocol was designed to systematically identify geometric elements, including types of three-dimensional shapes present, their dimensions, spatial relationships, and potential for decomposition analysis. Visual documentation captured the gate structure from multiple perspectives to facilitate detailed geometric analysis and to provide reference materials for potential educational media development. Interviews were conducted to understand the cultural significance of the gate structure, its historical background, and community perceptions regarding its educational potential.

Data analysis followed a systematic process of reduction, categorization, and interpretation aligned with qualitative research methodology. The geometric analysis phase involved identifying constituent three-dimensional shapes (rectangular prisms and cubes), measuring their dimensions, and mapping their spatial arrangements within the overall structure. Decomposition analysis examined how the composite gate structure could be broken down into simpler geometric components and subsequently reconstructed, simulating the cognitive processes students would engage in during learning activities. Cultural value analysis explored the ethnopedagogical dimensions embedded in the structure and tradition, identifying connections between mathematical concepts and local wisdom principles.

Table 1: Research Design and Data Collection Methods

Aspect	**Description**	**Purpose**
Research Approach	Descriptive qualitative	To provide detailed analysis of geometric structure and cultural context
Research Location	Mbah Buyut Ki Tuan Tomb, Karanglo Village, Tuban	Site of cultural tradition and architectural structure
Time of Study	During Manganan tradition, Dzulhijjah	To observe cultural practice and physical structure simultaneously
Primary Data Sources	Direct observation, visual documentation, measurements	To analyze geometric properties and spatial composition
Secondary Data Sources	Semi-structured interviews with caretaker and community members	To understand cultural significance and historical context
Key Informant	Mbah Modin Wahap Kusmiyarto, S.Pd.I	Tomb caretaker with extensive cultural-historical knowledge

Data Collection Instruments	Observation protocol, digital camera, measuring tools, interview guide	To ensure systematic and comprehensive data gathering
Analysis Techniques	Geometric decomposition analysis, cultural value interpretation, data triangulation	To identify learning potential and ethnopedagogical dimensions
Validation Method	documentation, and interview data	To ensure reliability and validity of findings

RESULTS AND DISCUSSION

The geometric analysis of the Mbah Buyut Ki Tuan Tomb gate revealed a composite structure comprising multiple three-dimensional shapes that can be systematically decomposed and reconstructed for educational purposes. The overall gate structure measures approximately 3.5 meters in height and 2.8 meters in width, featuring a symmetrical design that facilitates pattern recognition and geometric analysis. The main architectural components identified include vertical pillars, horizontal foundation elements, and decorative ornamental sections at the apex, each representing distinct geometric forms suitable for elementary-level mathematics instruction.

The vertical pillars constitute the primary structural elements of the gate, each representing rectangular prisms with clearly defined dimensions. The left and right pillars measure approximately 2.8 meters in height, 0.4 meters in width, and 0.4 meters in depth, creating elongated rectangular prisms that students can easily identify and measure. These pillars are positioned symmetrically on either side of the gate opening, providing opportunities for students to observe geometric congruence and spatial relationships. The rectangular prism shape of the pillars can be decomposed into faces (rectangles), edges, and vertices, allowing students to explore properties of three-dimensional shapes including surface area and volume calculations. The uniformity of the pillars also enables comparative analysis and reinforces concepts of geometric transformation and symmetry.

The foundation and base structure of the gate consists of multiple rectangular prisms arranged in layers, creating a stepped platform effect. The base platform measures approximately 3.2 meters in length, 1.2 meters in width, and 0.6 meters in height, representing a large rectangular prism that supports the entire structure. Above this base, smaller rectangular prism elements are arranged to create transitional levels leading to the pillars, with dimensions varying from 0.3 to 0.5 meters in each direction. This layered arrangement demonstrates the principle of composite shapes formed by combining multiple simple geometric elements. Students can practice decomposition by identifying individual rectangular prisms within the foundation and calculating their respective volumes, then combining these to determine the total volume of the foundation structure.

The ornamental section at the apex of the gate features cubic and near-cubic elements that crown the structure and provide decorative detail. The central ornament consists of a cube with edge lengths of approximately 0.35 meters, positioned symmetrically above the gate opening. Flanking this central cube are smaller cubic ornaments with edge lengths ranging from 0.2 to 0.25 meters, arranged in a balanced composition that emphasizes symmetry and proportion. These cubic elements provide ideal examples for teaching cube properties, including equal edge lengths, right angles, and relationships between surface area and volume. The contrast between the elongated rectangular prisms of the pillars and the compact cubes of the ornaments offers opportunities to compare and contrast different three-dimensional shapes and their properties.

The composite nature of the gate structure enables multiple levels of decomposition analysis suitable for differentiated instruction. At the most basic level, students can identify the three primary shape types present: tall rectangular prisms (pillars), flat rectangular prisms (foundation layers), and cubes (ornaments). Intermediate-level analysis involves counting the number of each shape type and describing their spatial relationships using directional language such as above, below, beside, and between. Advanced decomposition requires students to mentally disassemble the entire structure into individual components, assign dimensions to each element, calculate individual volumes and surface areas, and then reconstruct the composite shape by specifying how components fit together. This progressive complexity allows teachers to scaffold instruction according to students' developmental readiness and prior knowledge.

Table 2: Geometric Elements of the Tomb Gate Structure

Component	Shape Type	Approximate Dimensions (meters)	Quantity	Educational Function
Vertical Pillars	Rectangular Prism	H: 2.8, W: 0.4, D: 0.4	2	Identifying elongated prisms, symmetry, congruence
Base Platform	Rectangular Prism	L: 3.2, W: 1.2, H: 0.6	1	Large-scale volume calculation, foundation concept
Foundation Layers	Rectangular Prism	Variable: 0.3-0.5 per dimension	4-6	Composite shapes, layered arrangement, combination
Central Ornament	Cube	Edge: 0.35	1	Cube properties, equal dimensions, symmetry
Side Ornaments	Cube	Edge: 0.2-0.25	4	Comparing cube sizes, proportion, pattern
Gate Opening	Negative Space	H: 2.0, W: 1.2	1	Spatial reasoning, subtraction of volume

The decomposition process applicable to this structure follows a systematic sequence that mirrors computational thinking principles. First, students observe the complete structure and identify its overall shape and purpose as a gate or entryway. Second, they recognize that the gate is not a single simple shape but rather a combination of multiple geometric forms. Third, they begin identifying individual shapes within the structure, starting with the most prominent elements such as the tall pillars and progressing to smaller details like the ornamental cubes. Fourth, students describe the position and orientation of each identified shape using spatial vocabulary. Fifth, they estimate or measure the dimensions of each component shape. Sixth, students practice reconstructing the structure conceptually by specifying how the individual shapes connect and relate to one another. Finally, they can create representations of the structure through drawings, physical models, or digital simulations that demonstrate their understanding of the decomposition and reconstruction process.

The educational potential of the gate structure extends beyond pure geometric analysis to include critical thinking development through problem-solving scenarios. Students can be challenged with questions such as: How many rectangular prisms are needed to build the foundation? If each cube ornament is removed, how would the appearance change? What is the total volume of all cubic elements combined? How much material would be required to construct a similar gate at half scale? These questions require students to apply decomposition skills, perform calculations, engage in proportional reasoning, and synthesize information to arrive at solutions. The authentic context of a real cultural structure enhances motivation and demonstrates the practical applications of mathematical concepts in architecture and design.

Table 3: Decomposition Analysis Framework for Educational Implementation

Analysis Level	Student Activity	Cognitive Skills Developed	Sample Questions
Recognition	Identify overall structure and purpose	Observation, categorization	"What is this structure? What shapes do you see?"
Identification	Name individual geometric shapes present	Shape recognition, vocabulary	"Point to the rectangular prisms. Where are the cubes?"
Enumeration	Count quantity of each shape type	Counting, classification	"How many rectangular prisms form the pillars?"
Spatial Description	Describe positions and relationships	Spatial reasoning, directional language	"Where is the cube located relative to the pillars?"
Measurement	Estimate or measure dimensions	Measurement skills, estimation	"How tall is each pillar? What is the cube's edge length?"
Calculation	Compute volume and surface area	Arithmetic application, formula use	"Calculate the volume of one pillar."
Reconstruction	Explain how shapes combine	Synthesis, part-whole relationships	"How would you rebuild this gate using simple shapes?"
Problem-Solving	Apply concepts to novel scenarios	Critical thinking, transfer	"How would you modify the design to make it taller?"

The cultural and ethnopedagogical dimensions of the gate structure provide additional layers of educational value beyond mathematical content. The gate serves as the entrance to a sacred site where the Manganan tradition honors Mbah Buyut Ki Tuan, a historical figure who contributed to the spread of Islam in the region and maintained family ties with Sunan Bonang. This historical connection imbues the structure with cultural significance that extends beyond its physical form. When students learn mathematics through analysis of this gate, they simultaneously engage with their cultural heritage, learn about important historical figures in their community, and develop appreciation for the architectural achievements of their ancestors. This holistic learning approach aligns with ethnopedagogical principles that recognize the inseparability of knowledge systems from cultural contexts.

The symbolism embedded in the Manganan tradition's ritual foods—bucu (cone-shaped rice), roasted chicken, and coconut sambal—offers parallel lessons in character education that complement the mathematical learning. Just as the gate structure can be decomposed into constituent shapes, the symbolic meanings of traditional foods can be analyzed to extract ethical principles such as humility, self-control, and social usefulness. This parallel between geometric decomposition and cultural analysis reinforces critical thinking skills across domains. Students learn to apply analytical thinking not only to mathematical objects but also to cultural practices and symbolic systems, developing metacognitive awareness of decomposition as a general problem-solving strategy applicable to diverse contexts.

The community values of gotong royong (mutual cooperation) evident in the Manganan tradition provide a social-emotional learning dimension to complement cognitive skill development. When students engage in collaborative activities to analyze the gate structure, measure its components, create models, or develop digital representations, they enact the same cooperative spirit that characterizes the community tradition. This experiential connection between learning process and cultural values deepens students' understanding of both mathematics and their cultural identity. The integration of social-emotional and cognitive learning objectives represents best practice in culturally responsive education that recognizes the whole child and the complete cultural context.

Table 4: Ethnopedagogical Values Integrated with Mathematical Learning

Ethnopedagogical Value	Cultural Source	Mathematical Connection	Learning Outcome
Respect for Ancestors	Veneration of Mbah Buyut Ki Tuan	Studying architectural legacy	Cultural identity, historical awareness

Spiritual Reflection	Haul commemoration tradition	Mindful analysis of sacred structure	Ethical reasoning, purposeful learning
Mutual Cooperation	Gotong royong in Manganan	Collaborative geometric analysis	Teamwork, communication skills
Community Solidarity	Shared meal tradition	Group problem-solving activities	Social cohesion, collective achievement
Humility	Bucu symbolism (cut apex)	Recognizing limitations in problem-solving	Growth mindset, intellectual humility
Usefulness	Coconut sambal symbolism	Applying mathematics to real problems	Purpose, relevance, application
Cultural Preservation	Maintaining tradition across generations	Documenting and analyzing heritage structures	Stewardship, intergenerational connection

Visual documentation of the gate structure reveals additional pedagogical affordances for different instructional modalities. Front-view photographs clearly show the symmetry and proportions of the gate, enabling students to identify congruent shapes and equal dimensions. Side-view images reveal the depth of the pillars and foundation, providing perspective on three-dimensional space that is difficult to capture in two-dimensional representations. Close-up photographs of ornamental details allow examination of cubic forms and their arrangement. These multiple perspectives support the development of spatial visualization skills as students mentally rotate and manipulate the structure in their minds. The availability of diverse visual resources accommodates different learning styles and provides scaffolding for students who struggle with spatial reasoning tasks.

Figure 1: Front view of Mbah Buyut Ki Tuan Tomb gate showing symmetrical pillar arrangement and overall structure

Figure 2: Close-up view of upper ornamental section displaying cubic elements

Figure 3: Physical model constructed by students using blocks to replicate gate structure

The feasibility of integrating this cultural structure into formal mathematics instruction has been preliminarily validated through informal educational activities conducted during the Manganan tradition observation. Students who participated in guided observation of the gate structure demonstrated engagement and curiosity, asking questions about the shapes they observed and attempting to count the number of different elements. When provided with blocks and encouraged to recreate a simplified version of the gate, students successfully identified the need for tall rectangular pieces for pillars and small cubes for ornaments, demonstrating intuitive understanding of decomposition principles. These preliminary observations suggest that the gate structure is developmentally appropriate for elementary students and can serve as an effective concrete referent for abstract geometric concepts.

The findings of this research demonstrate that the Mbah Buyut Ki Tuan Tomb gate possesses significant pedagogical value as a contextual learning resource for three-dimensional geometry, particularly for developing decomposition skills and critical thinking in elementary students. The clear identification of rectangular prisms and cubes within the gate structure aligns with curriculum standards for elementary geometry, which typically introduce these fundamental three-dimensional shapes as building blocks for more complex spatial understanding (Molina-Ayuso et al., 2023). The systematic decomposition of the gate into constituent geometric elements mirrors the computational thinking processes that have been identified as essential for mathematical problem-solving in the digital age (Adiyastuti et al., 2024; Wu et al., 2024). By engaging with a culturally meaningful architectural structure, students can develop both mathematical competencies and cultural literacy simultaneously, addressing multiple learning objectives within an integrated instructional framework.

The ethnopedagogical approach evident in this study corresponds with recent research emphasizing the effectiveness of culturally responsive mathematics instruction for enhancing student achievement and engagement. Studies by Larasati et al. (2025) and Nurtriana & Nuryadi (2025) demonstrate that integrating local cultural elements into mathematics lessons significantly improves conceptual understanding, critical thinking, and student confidence compared to conventional instructional methods. The tomb gate represents an authentic cultural artifact that carries historical significance and community value, distinguishing it from artificial or contrived examples that lack genuine cultural connections. This authenticity is crucial for ethnopedagogical approaches to be effective, as students recognize and appreciate the real-world relevance of their learning (Zainovi et al., 2025) Wulandari et al., 2024). The gate's role in the Manganan tradition provides rich cultural context that transforms mathematics learning from abstract symbol manipulation into meaningful engagement with community heritage.

The decomposition analysis framework developed in this study addresses a critical gap in elementary mathematics education identified in recent literature. Research by Susanti et al. (2025) indicates that decomposition skills, while foundational to computational thinking and problem-solving, often receive insufficient explicit attention in elementary curricula. Students frequently struggle to break down complex geometric structures into manageable components, limiting their ability to analyze, understand, and solve spatial problems (Arvi et al., 2025; Supiarmo et al., 2022). The systematic approach to decomposing the gate structure—from initial observation through component identification to reconstruction—provides a concrete model for teaching decomposition strategies that students can transfer to other mathematical contexts. This explicit instruction in decomposition as a cognitive strategy represents best practice in developing students' metacognitive awareness and strategic competence.

The multilevel analysis opportunities presented by the gate structure enable differentiated instruction that accommodates diverse student readiness levels and learning trajectories. Elementary students exhibit considerable variation in spatial reasoning abilities and prior geometric knowledge, necessitating flexible instructional approaches that can be adapted to individual needs (Jiang & Li, 2021). The gate structure supports differentiation through varying cognitive demands: basic shape recognition for beginning learners, spatial relationship description for intermediate students, and volumetric calculation with reconstruction for advanced learners. This progressive complexity allows teachers to implement the same cultural resource across grade levels or within mixed-ability classrooms, maximizing instructional efficiency while ensuring all students can access meaningful learning experiences. The scaffolded approach to decomposition analysis also provides a framework for formative assessment, as teachers can identify students' current level of understanding and provide targeted support for advancement to higher cognitive levels.

The integration of digital technology, particularly Scratch programming, with ethnopedagogical content creates powerful synergies that enhance both computational thinking and cultural appreciation. Research demonstrates that Scratch-based geometry instruction significantly improves students' motivation, collaboration, and critical thinking skills (Molina-Ayuso et al., 2023; Setiawan et al., 2025; Winarko, 2024). When students create digital representations of the tomb gate in Scratch, they must engage in precise geometric reasoning to specify shape dimensions, positions, and relationships using programming commands. This computational process reinforces mathematical concepts while developing algorithmic thinking and problem-solving strategies. Furthermore, the cultural significance of the gate imbues the programming activity with authentic purpose, transforming what could be a purely technical exercise into a meaningful project of cultural documentation and preservation. This combination of mathematical rigor, technological skill development, and cultural engagement exemplifies twenty-first-century learning objectives that prepare students for an increasingly interconnected world.

The potential for augmented reality applications to enhance learning experiences with the tomb gate structure represents an exciting frontier for ethnomathematics education. Recent studies by Gustina et al. (2025) and Maharbid et al. (2025) demonstrate that AR-based ethnomathematics learning media significantly improve spatial ability and student engagement in geometry instruction. An AR application featuring the tomb gate could allow students to virtually manipulate the structure, separating it into component shapes, rotating it to view from different angles, and reassembling it through interactive gestures. Such technology-enhanced experiences provide affordances not possible with physical observation alone, particularly for developing dynamic spatial visualization skills. The AR approach also addresses practical constraints of conducting field-based learning, as students could interact with high-fidelity digital representations of the gate structure regardless of physical location or time constraints, extending access to this valuable learning resource beyond the immediate community.

The critical thinking development fostered through geometric analysis of cultural structures extends beyond purely mathematical reasoning to encompass broader analytical and evaluative skills. When students investigate why the gate was designed with particular proportions, materials, and decorative elements, they engage in historical and cultural inquiry that develops questioning skills and evidence-based reasoning (Rahayu et al., 2025; Sofiah et al., 2025). Comparing the tomb gate structure with other traditional architectural forms encourages comparative analysis and pattern recognition across contexts. Evaluating the structural integrity and aesthetic qualities of the design involves making judgments based on multiple criteria, developing evaluative thinking skills. These higher-order thinking processes, initiated through mathematical decomposition analysis, cultivate habits of mind that support academic achievement across disciplines and problem-solving competence in daily life.

The social-emotional learning dimensions of culturally embedded mathematics instruction contribute to holistic student development that encompasses affective as well as cognitive domains. Research by Lubis et al. (2024) and Atmojo et al. (2025) highlights how ethnomathematics approaches strengthen students' cultural identity, sense of belonging, and motivation to learn. When students' cultural backgrounds are validated and incorporated into academic content, they experience increased self-efficacy and engagement, particularly for students from marginalized or underrepresented communities. The collaborative activities involved in studying the tomb gate—field visits, group measurements, collective model building—foster social skills such as communication, cooperation, and conflict resolution that are essential for success in school and society. The connection between academic learning and community traditions also promotes family involvement in education as parents and elders become resources for cultural knowledge, strengthening home-school partnerships and recognizing the educational expertise present in communities.

The sustainability and scalability of ethnopedagogical approaches depend on systematic documentation and resource development that enables widespread implementation beyond individual pilot projects. This research provides a model for analyzing cultural structures' mathematical properties and pedagogical affordances that can be replicated with other local artifacts and traditions. The framework for decomposition analysis and the categorization of geometric elements offer templates for teachers to adapt to their own community contexts, whether analyzing traditional buildings, ceremonial objects, textile patterns, or agricultural practices. Professional development programs that equip teachers with skills for identifying and leveraging local cultural resources for mathematics instruction represent crucial infrastructure for expanding ethnopedagogical practices (Erfan et al., 2025; Olsson & Granberg, 2024). Digital repositories of analyzed cultural structures, including measurements, photographs, and lesson plans, could facilitate resource sharing among educators and preserve documentation of cultural heritage for future generations.

The theoretical implications of this research contribute to evolving frameworks for culturally responsive STEM education that recognize the legitimacy and value of diverse knowledge systems. Traditional mathematics education has often privileged abstract, decontextualized approaches that ignore or devalue the mathematical practices embedded in cultural traditions (Permana, 2023; Putri et al., 2024). Ethnopedagogical perspectives challenge this narrow view by demonstrating that sophisticated mathematical thinking exists in architectural design, artistic creation, and practical problem-solving within cultural contexts. Recognizing the tomb gate as a site of mathematical knowledge validates community expertise and disrupts deficit narratives that position some students and communities as lacking mathematical ability. This epistemological shift toward pluralistic conceptions of mathematical knowledge aligns with social justice principles in education that seek to create equitable learning opportunities and honor the dignity and contributions of all cultural groups.

CONCLUSION

This research has successfully demonstrated that the geometric structure of the Mbah Buyut Ki Tuan Tomb gate in Karanglo Village, Tuban, possesses substantial pedagogical value as a contextual learning resource for teaching decomposition of three-dimensional shapes and developing critical thinking skills in elementary students. The systematic analysis revealed that the gate structure comprises clearly identifiable rectangular prisms and cubes arranged in a composite configuration that facilitates progressive levels of geometric analysis, from basic shape recognition through advanced decomposition and reconstruction. The framework developed for analyzing the gate's geometric elements provides educators with a replicable approach for leveraging cultural artifacts in mathematics instruction, demonstrating how authentic community resources can be systematically incorporated into formal curriculum. The integration of mathematical content with ethnopedagogical values creates multidimensional learning experiences that simultaneously develop students' cognitive skills, cultural identity, and social-emotional competencies.

The findings establish a preliminary foundation for developing ethnopedagogy-based digital learning media, particularly using platforms like Scratch, to create engaging and culturally meaningful geometry instruction. The tomb gate structure's suitability for both physical observation and digital representation enables diverse pedagogical approaches including field-based learning, hands-on modeling activities, and technology-enhanced instruction through augmented reality or programming environments. Future research should focus on developing and empirically testing specific instructional materials and digital tools based on this cultural resource, measuring their effectiveness in improving students' decomposition skills, spatial reasoning, and critical thinking compared to conventional instruction. Additionally, expanding this research model to document and analyze other cultural structures and traditions throughout Indonesia and globally would contribute to building a comprehensive knowledge base for ethnomathematics education that respects and celebrates the mathematical wisdom present in diverse cultural traditions.

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