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Contextual numeracy learning through a culturally responsive–ethnomathematics (CReM) model using *Joglo Jompongan* architecture

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Abstract

Although research on culturally responsive pedagogy and ethnomathematics continues to grow, empirically grounded models for systematically integrating cultural contexts into numeracy-oriented geometry instruction remain limited. This study aimed to develop and evaluate a contextual numeracy learning model based on Culturally Responsive–Ethnomathematics (CReM) using the architectural features of the Joglo Jompongan. Research and Development (R&D) with design thinking was employed with 22 junior high school equivalent learners at a Community Learning Activity Center (Package B). Data were collected through interviews, classroom observations, and student activity sheets and were analyzed descriptively. The findings indicate notable improvements in students' understanding of plane and solid geometry, as well as in their ability to connect mathematical concepts with culturally situated contexts. High levels of learning engagement and cultural awareness were also observed. Embedding geometric ideas within familiar architectural elements supported students' construction of mathematical meaning from lived experiences, offering an adaptable framework for culturally responsive and conceptually grounded numeracy instruction.

Keywords: culturally responsive teaching; design thinking; ethnomathematics; *Joglo Jompongan;* numeracy

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Introduction

At the secondary level, mathematics learning, particularly geometry, continues to face challenges in connecting abstract concepts with students' real life contexts. International studies indicate that the absence of culturally relevant contexts limits students' understanding of geometric concepts as well as their spatial reasoning and numeracy development. (Ann et al., 2024; Hunter & Miller, 2022; Sapkota, 2023; Shahbari & Daher, 2020; Sorge et al., 2023). Similar conditions are evident in Indonesia, where limited exposure to local cultural artifacts constrains students' understanding of spatial structures and numeracy, leading to low levels of conceptual understanding and passive learning engagement. (Aprinastuti & Kovács, 2025; Ja'faruddin & Naufal, 2023; Nursyahidah et al., 2025; Paramita et al., 2024). These findings suggest that mathematics instruction remains abstract and cognitively demanding when it is disconnected from students' cultural contexts.

In response, a growing body of research emphasizes the integration of cultural values into mathematics learning as a means of enhancing student engagement, sense of belonging, and learning outcomes (Gbormittah et al., 2025; Wachira, 2020). Culturally responsive pedagogy, including ethnomathematics, has been shown to bridge abstract mathematical concepts with real life experiences, thereby strengthening relevance, conceptual understanding, learner motivation, and learning engagement (Cambaya & Sariana, 2025; Sorge et al., 2023; Wibawa et al., 2025). International literature indicates that culturally responsive teaching supports meaning making, identity development, and authentic mathematical reasoning, and that ethnomathematics situates mathematical ideas within familiar cultural practices (Diaz et al., 2019; Ernawati et al., 2024; Stone et al., 2025). Studies indicate that linking geometry to cultural artifacts enhances spatial reasoning and problem solving across diverse contexts (Jainuddin & Herman, 2025). In Indonesia, the effectiveness of culturally responsive teaching increases when it is integrated with tangible cultural contexts, including architecture, art, and traditional practices (Kusi & Bonyah, 2025). Traditional architecture embodies geometric concepts including symmetry, proportion, area, and volume, supporting numeracy, spatial skills, and cultural appreciation (Aprinastuti & Kovács, 2025; Khoirotunnisa et al., 2025; Mulenga, 2025; Santoso & Julie, 2024; Siti Nurkhafifah et al., 2021).

Despite these contributions, a critical limitation persists, as prior studies on Indonesian traditional houses predominantly employ descriptive ethnomathematics approaches that emphasize the identification of geometric forms and cultural meanings (Zuliana et al., 2023). For example, (Aulia et al., 2025) related the functional transformation of the *Joglo Pencu Kudus* building from residence to pavilion to geometry learning. However, such studies seldom extend beyond descriptive analysis to develop and empirically test intervention based models for contextual numeracy, especially at the junior high school level.

Joglo Jompongan, a simple open structure supported by sixteen pillars *(saka)*, was historically used as a pavilion or communal space and has increasingly been repurposed as a communal hall in contemporary contexts (Hp et al., 2023). These functional transformations provide rich and authentic contexts for contextual numeracy activities, such as estimating spatial capacity, analyzing proportional relationships, and calculating construction quantities.

Nevertheless, existing research predominantly remains at a descriptive level, focusing on the identification of geometric elements and cultural symbolism. Such studies have not yet advanced toward the development of intervention-based learning models that systematically integrate the functional transformation of *Joglo Jompongan* within a Culturally Responsive–Ethnomathematics (CReM) framework. Consequently, the potential of traditional architecture as a vehicle for strengthening real-life numeracy, particularly at the junior high school level, remains underexplored and empirically unvalidated (Safitri, 2023).

Architectural elements such as pavilions and central structures provide culturally grounded contexts for exploring ratios, congruence, and spatial balance in geometry learning (Prahmana & D'Ambrosio, 2020). Aligned with ethnomathematical perspectives, indigenous architectural artifacts can support numeracy development and conceptual understanding by connecting geometric ideas with culturally meaningful spatial representations (Wahyu et al., 2021). Contextual numeracy can be further enhanced through real-life mathematical tasks that emphasize both computation and application (Susanta et al., 2023). Within the context of *Joglo Jompongan*, students can engage in reflective learning tasks, such as analyzing how pavilion dimensions influence supporting structures or how roof inclination affects volume, thereby meaningfully connecting mathematics, cultural context, and social function (Cintyawati & Suniasih, 2024; Munthahana et al., 2023).

Taken together, these studies highlight a clear research gap between descriptive ethnomathematics research and the need for design-oriented, intervention based *CReM* models that systematically integrate cultural contexts into contextual numeracy learning. Addressing this gap, the present study develops and evaluates a *CreM* based contextual numeracy learning model using *Joglo Jompongan* through a Research and Development with Design Thinking. The study aims to examine how the model is developed, how its implementation affects students' numeracy skills and conceptual understanding of area and volume, and how it influences learning engagement and cultural awareness in geometry learning.

Methods

This research used the Research and Development (R&D) with Design Thinking approach developed by (Koroglu & Yildiz, 2022). The framework was selected due to its systematic learner-centered orientation, emphasis on empathic inquiry, and iterative refinement of instructional designs. Through the Design Thinking stages, the cultural and architectural features of the Joglo Jompongan were systematically examined and translated into geometry learning activities, ensuring alignment with the principles of Culturally Responsive Teaching (CRT), which emphasize the integration of learners' cultural backgrounds into mathematical meaning making (Stone et al., 2025). Ethical standards were upheld through informed consent obtained from students, teachers, and institutional authorities, with participation remaining voluntary and all data treated confidentially.

The study was conducted at the Center of Community Learning Activity (PKBM) *Ash Shahabah, Gondangrejo* District, *Karanganyar* Regency, a region with strong cultural associations with *Joglo* architecture. The participants comprised 22 Package B (Grade IX equivalent) learners engaged in geometry oriented numeracy learning. Field based learning activities were carried out at *Joglo Wirorejan*, *Boyolali* Regency, Central Java, selected for its authenticity and architectural relevance to the learning context. The integration of culturally grounded contexts supported students' conceptual understanding of geometry while facilitating the internalization of cultural values through meaningful learning experiences (Sarah & Batiibwe, 2024). The research procedures followed the five phases of Design Thinking, namely empathize, define, ideate, prototype, and test (Cintyawati & Suniasih, 2024; Stone et al., 2025).

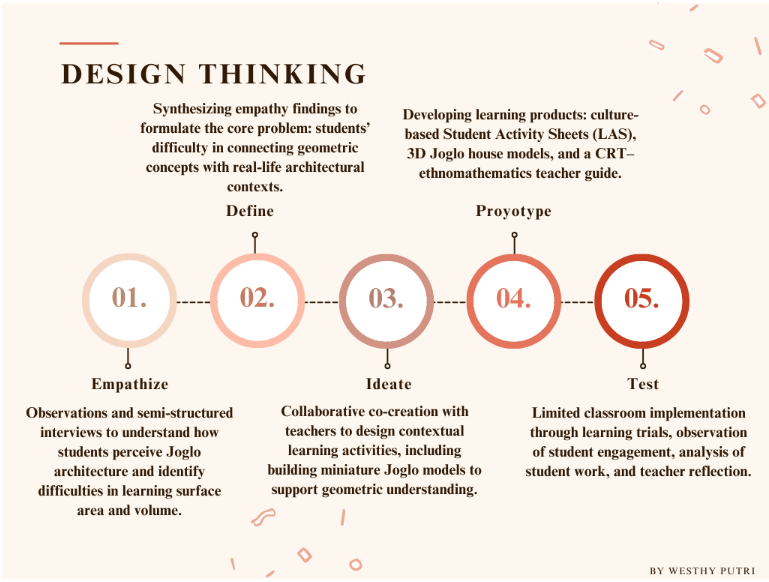


Figure 1. Design thinking process

During the empathize phase, classroom observations and semi structured interviews were conducted to examine students' perceptions of *Joglo* architecture and their difficulties in understanding area and volume concepts. The resulting data were synthesized in the define phase to identify the core instructional problem, namely the limited connection between abstract geometric concepts and real life architectural contexts. In the ideate phase, researchers and teachers collaboratively designed contextual learning activities, including the construction of miniature *Joglo* models to support conceptual understanding of surface area and volume. The prototype phase involved the development of culture based Student Activity Sheets (SAS), three dimensional *Joglo* models, and a CRT ethnomathematics oriented teacher guide that integrated cultural values with geometry content. The test phase consisted of limited classroom trials involving all 22 participants, with a focus on student engagement, analysis of student work, and teacher reflections.

The research instruments comprised numeracy tests, Student Activity Sheets (SAS), interview protocols, and classroom observation sheets. Instrument validity was established through expert judgment involving three specialists in mathematics education and instructional design, with evaluation criteria including content relevance, conceptual accuracy, cultural appropriateness, and instructional clarity. Numeracy test responses were assessed using analytic scoring rubrics and analyzed descriptively through pre and post test comparisons.

An explanatory mixed methods design was adopted, in which quantitative pre post data were used to examine changes in students' numeracy performance, while qualitative data were employed to explain and enrich the quantitative findings. Trustworthiness was ensured through methodological triangulation, peer debriefing, and prolonged engagement. This approach aligns with Design Thinking and Culturally Responsive Pedagogy principles, emphasizing iterative refinement and contextual sensitivity (Nolan & Xenofontos, 2023).

This study aimed to produce a contextual numeracy learning model grounded in the *Joglo Jompongan* context that enhances students' geometric understanding and cultural awareness, along with a practical CRT ethnomathematics based instructional guide to support inclusive, adaptive, and culturally responsive mathematics teaching in community learning centers.

Results

Empathize phase

The empathize phase, brief interviews and classroom observations were conducted to explore students' learning experiences and difficulties in geometry. The findings indicated that many students experienced challenges in understanding area and volume concepts and perceived geometry learning as abstract and monotonous. Teacher interviews further revealed a tendency for students to rely on formula memorization rather than conceptual understanding. Based on these insights, the *Joglo Jompongan* building (**Figure 2**) was identified as a relevant local cultural context, as it embodies geometric elements such as rectangles, triangles, trapezoids, and triangular prisms. Its familiarity within the local environment positioned the *Joglo Jompongan* as a meaningful and accessible context for supporting students' conceptual engagement with geometry.

(a) (b)

Figure 2. (a) *Wirorejan Joglo* pavilion; (b) Geometry formed

Figure 3. Inside view of the *Joglo*

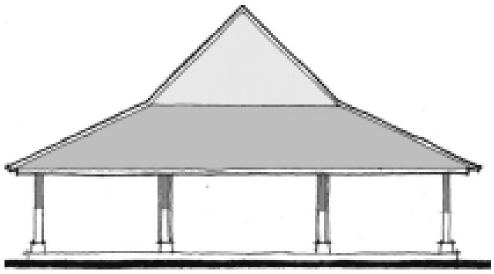
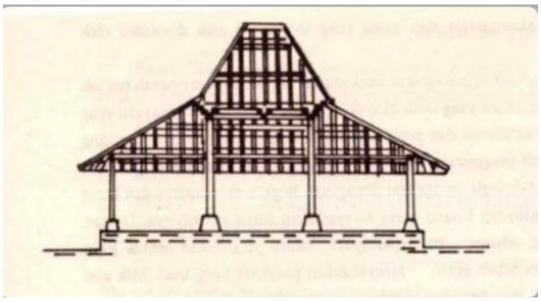


Figure 4. Side sketch of *Joglo Jompongan*


(a)

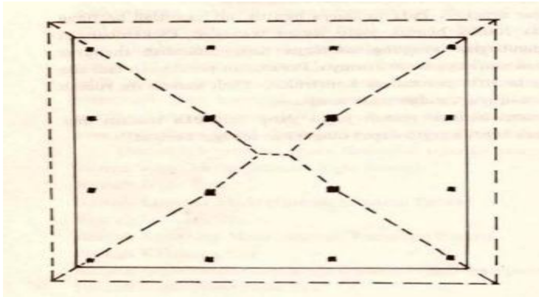
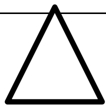
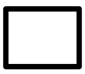
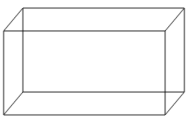
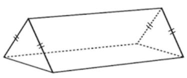

(b)

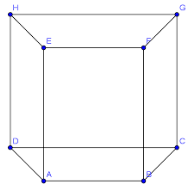
Figure 5 . (a) Sketch of the front view of a *Joglo Jompongan*; (b) The sketch of the roof
https://rumah.alunalun.info/detailrumah/Joglo%20Jompongan

Define phase

Based on the findings from the empathize phase, the define phase articulated the primary instructional problem, namely students' difficulty in connecting geometric concepts, particularly area, perimeter, and volume, to real world architectural forms. Analysis of visual documentation and field observations revealed multiple geometric structures embedded in the *Joglo Jompongan* building, including rectangles, triangles, trapezoids, triangular prisms, and rectangular prisms, as observed in the roof construction, supporting pillars *(saka),* and floor layout. These architectural elements are illustrated in **Figures 2** to **4**.

Table 1. Formed geometry and conceptualization

Building Parts	Geometric Shapes	Geometric Names	Contextualized Mathematical Concepts
Roof peaks on the sides		Isosceles triangle	Pythagorean theorem (height/hypotenuse), trigonometry (roof slope angles)
Stepped tile and saka base or pillar stand		Trapezoid	Surface area (roofing material), trapezoidal symmetry
Main pillars (*saka guru)*		Rectangle	Parallel lines, ratio (pole height vs. Diameter) in algebra.
Entrance stairs		Rectangle	Parallel lines, arithmetic sequences (step distance, height)
The floors		Square	Area and perimeter (tiling costs), space capacity (contextual numeracy)
Saka poles and stairs		Block	Volume of wood, surface area for painting
Main Roof (Core)		Triangular prism	Volume & Surface Area (modeling truncated quadrilateral pyramid for Junior High School)

Building Parts	Geometric Shapes	Geometric Names	Contextualized Mathematical Concepts
Perimeter roof (terrace)		Trapezoidal prism	Area & Volume applications in traditional Javanese buildings

This analysis maps classroom geometric concepts to observable elements of the *Joglo Jompongan*. The architectural features illustrate how area and volume concepts are embedded in traditional buildings within students' local environment.

Ideate phase

The ideate phase generated a set of contextual numeracy activities for the CReM model grounded in *Joglo Jompongan* architecture. Informed by the findings from the empathize and define phases, teachers and researchers collaboratively designed learning activities that linked architectural features such as symmetry, proportion, and spatial structures to geometric concepts including area, volume, and ratios. The resulting outputs comprised structured learning scenarios, contextual problem tasks, and activity designs intended for subsequent prototype development.

Table 2. CReM contextualized numeracy learning ideas and design.

Activities	Activity Description	Numeracy Concepts Develop	Integrated Cultural Values	Output / Student Product
Visual exploration and cultural discussion	Observe 3d model or image of *joglo jompongan*, identify geometric shapes, discuss cultural meaning.	Flat & spatial shapes, proportion, symmetry	Balance and harmony	Observation notes, diagrams of shapes
Redrawing roof plan and structure	Redraw roof plan and sections using paper or simple design apps	Scale, comparison, area of flat shapes.	Thoroughness, orderliness	Redrawn plans and diagrams
Calculating building area and volume	Calculate wall area, floor area, and volume of main room and roof	Area of rectangles, triangles, trapezoids; volume of blocks/prisms	Alignment of function and aesthetics.	Calculation tables, representations
Mathematical modeling of *joglo*	Construct models to estimate material requirements (roof tiles, wood volume)	Modeling, counting, units of measure	Mutual cooperation, local wisdom	Simple contextual math models

Activities	Activity Description	Numeracy Concepts Develop	Integrated Cultural Values	Output / Student Product
Mathematics-culture presentation and reflection	Present results linking geometry concepts to *joglo* symbolism	Communication, reflective thinking.	Cultural appreciation, local identity.	Poster or reflective report.

The learning activities at this stage link numeracy concepts to the observable architectural elements of the *Joglo Jompongan* building, integrating cultural features and local heritage documented as part of the learning context

Prototype phase

The prototype phase involved the concretization of learning ideas generated during the ideate phase. At this stage, these ideas were transformed into classroom ready instructional products that integrated *Joglo Jompongan* architectural features with geometry and numeracy content. Prototyping was conducted collaboratively by researchers and junior high school mathematics teachers, taking into account the results of the needs analysis and students' characteristics. Three primary products were developed: (1) the CReM *Joglo Jompongan* Student Activity Sheet (SAS), (2) a three dimensional *Joglo Jompongan* model as visual numeracy media, and (3) the CReM ethnomathematics oriented Teacher's Guide. Each product is described below.

a) Student Activity Sheet (SAS)
   The SAS contains sequential activities: observing architectural elements, performing measurements, analyzing geometric shapes, and solving contextual numeracy problems based on the *Joglo Jompongan* structure.

Table 3. Structure and content of student activity sheet (SAS) based on CReM model (culturally responsive-ethnomathematics)

CReM Stage	Learning Goals	Activity Description	Numeracy Gometry Focus	Culture and Character Values
Cultural awareness and exploration	Recognize *joglo jompongan* as a cultural artifact and identify geometric shapes	Observe pictures or 3d models of *joglo*, mark roofs, poles, walls, and identify corresponding flat/3d shapes	Introduction to simple 2d and 3d shapes	Curiosity, pride in local culture
Ethnomathe matical connection	Relate cultural functions to math concepts	Analyze the relationship between architectural forms, functions, and philosophical meanings (e.g., roof slope = balance, pole = support)	Comparison, symmetry, proportion.	Balance, local wisdom, cooperation
Numerical application	Apply geometry and numeracy in context.	Measure or estimate roof area, room volume, or	Area, volume,	Accuracy, logical

CReM Stage	Learning Goals	Activity Description	Numeracy Gometry Focus	Culture and Character Values
		ratios of house parts using formulas	ratio, comparison	thinking, responsibility
Reflection & cultural appreciation	Reflect on culture-based learning in math.	Write a reflection on how studying *joglo* improved math understanding and cultural appreciation	Reflective reasoning in geometry and numeracy	Cultural appreciation, self-awareness, national pride

An example of an activity included in the SAS requires students to identify plane geometric shapes represented in the *Joglo Jompongan* building illustration and to calculate the area of architectural elements based on given measurements. The task includes calculating the area of a rectangular front wall (4 m × 3 m) and the area of a triangular roof section with a base of 4 m and a height of 2.5 m.

b) 3D Model of Joglo Jompongan Building

A three-dimensional (3D) model of the *Joglo Jompongan* building was developed as a visual and manipulative learning medium during the prototype stage. The model represents a miniature form of the *Joglo Jompongan* building and was constructed using simple materials such as ice cream sticks, wood glue, and cardboard. The construction process involved assembling structural components that represent architectural elements of the *Joglo Jompongan* building. Through the model, spatial elements such as beams, prisms, pyramids, and triangular forms were represented in accordance with the building structure.

Figure 6. 3D model of *Joglo Jompongan* building

The model depicts key architectural components, including the multi-tiered roof, main walls, supporting pillars *(saka guru*), floor, and entrance. Used in group activities, students measured elements, recorded data, and compared results with geometric calculations, fostering hands-on understanding of area, volume, and proportional relationships..

c) CReM (Culturally Responsive-Ethnomathematics) Teacher's Guide

The guide was developed to support classroom implementation of the CReM model. It presents the pedagogical principles, structured learning sequences, and examples of guiding and reflective questions that integrate numeracy concepts with *Joglo Jompongan* architectural elements and local cultural contexts.

Table 4. CReM-based teacher's guide

Teacher guide section	Content and purpose
Introduction	Explains the philosophy and principles of the CReM model for contextualized numeracy learning.
Learning steps	1. Cultural exploration: teacher introduces *joglo* house stories and symbols. 2. Mathematical discovery: students explore area, volume, and comparison concepts. 3. Cultural reflection: students connect cultural meanings to mathematical concepts.
Reflection leading question	How does the balance of the joglo structure relate to life balance? How does the roof's symmetry reflect harmony in javanese culture? What patterns in traditional houses can inform math and life?
Evaluation and assessment	Conducted through observation, worksheets, group discussions, and written reflections. Focus is on reasoning, representation, and cultural understanding.

At the end of the prototype stage, the study produced a set of CReM-based learning products using the Joglo Jompongan context: (1) a Student Activity Sheet (SAS), (2) a three-dimensional Joglo Jompongan model, and (3) a CReM teacher's guide. Together, these products form the instructional framework developed in this study, with their characteristics and structure documented as key research outcomes.

Testing phase

The testing phase involved the implementation of the developed learning prototypes, including the Student Activity Sheet (SAS), the three dimensional *Joglo Jompongan* model, and the CReM Teacher's Guide, in a limited classroom trial. The pilot study was conducted at a Community Learning Activity Center (PKBM) with Package B students at the junior high school equivalent level over four sessions, each lasting 90 minutes. Learning activities in each session included guided observation, measurement tasks, contextual numeracy problem solving, and systematic documentation of student work.

Table 5. Implementation procedure

Meeting	Main activity	Learning goals
1 -2	Exploration of *joglo* house and flat shapes: teacher presents *joglo jompongan* via pictures/3d model; students identify shapes on roof, walls, doors; calculate area using simple measurements.	Recognize geometric shapes in local cultural context; understand area through contextual measurement.
3-4	Building volume and cultural reflection: students measure 3d model dimensions; calculate volume of blocks and prisms; reflect on the balance of the structure in relation to life values.	Calculate building volumes using real cultural context; understand and reflect on cultural values and the philosophy of balance.

Classroom observations showed high student engagement during learning activities, such as asking questions, measuring 3D model components, and discussing calculation results in groups. About 80% of students actively participated in hands-on and contextual tasks, while 70% could explain the relationship between geometric shapes and *Joglo Jompongan* architectural elements based on their activity sheets and oral responses. Student reflections indicated that 90% had positive attitudes toward learning geometry through cultural contexts. Improvements in numeracy, particularly in area and volume concepts, were documented through pre-test and post-test results.

Table 6. Pre and post test results

Aspects measured	**Description of indicator**	**Average Pre-test (%)**	**Average Post-test (%)**	**Improvement (%)**
Understanding the area of flat shapes	Identify and calculate the area of flat geometric shapes accurately	58	82	+24
Understanding the area and volume of a building	Determine surface area and volume of simple building structures	55	80	+25
Ability to relate concepts to real contexts	Apply geometric concepts to real-world architectural contexts (e.g., *Joglo* buildings)	50	85	+35

Student reflections indicated that learners perceived *Joglo* buildings as both cultural artifacts and representations of mathematical concepts, noting that visualization of architectural forms facilitated understanding of area and volume and fostered pride in connecting Javanese culture with mathematics. Teacher feedback highlighted that the SAS and 3D models enhanced contextual and collaborative learning, supporting conceptual understanding beyond abstract formulas and aligning with the Merdeka Curriculum principles. Teachers further recommended developing interactive digital modules to extend the model's applicability across offline and online learning environments.

Overall, the results indicate that integrating the *Joglo Jompongan* architectural context through the CReM model positively supported students' numeracy learning. Quantitatively, pre-test and post-test data showed notable improvements in students' understanding of area, volume, and contextual application of geometry concepts, with gains ranging from 24% to 35%. Qualitatively, classroom observations, student reflections, and teacher interviews revealed increased engagement, improved conceptual understanding, and positive attitudes toward geometry learning. Students were able to visualize abstract concepts through real architectural elements, while teachers reported that the use of culturally grounded media reduced reliance on rote formula memorization. These findings suggest that the CReM-based learning design effectively bridges mathematical concepts with local cultural contexts, enhancing both numeracy skills and cultural appreciation among Package B students.

Discussion

The results of this study indicate that integrating local cultural elements through the *Joglo Jompongan* building enhanced students' geometry performance and engagement. Beyond confirming previous ethnomathematics findings, these results can be interpreted through three complementary mechanisms: spatial visualization, active interaction with materials, and cultural proximity. The architectural structure of the *Joglo Jompongan* provides tangible three-dimensional representations of geometric forms, allowing students to visualize relationships among area, volume, and proportions more effectively than through abstract symbols alone. Hands-on engagement with sketches and 3D models further supports learning by enabling students to manipulate and explore geometric structures directly. Finally, the cultural familiarity of the Joglo Jompongan fosters emotional and cognitive proximity, reducing abstraction barriers and situating mathematics within students' lived experiences.

These findings are consistent with research in ethnomathematics and culturally responsive pedagogy, which suggests that embedding learning within familiar cultural contexts enhances conceptual understanding and numeracy development (Aribbay, 2025; Prahmana & D'Ambrosio, 2020; Zainovi & Mariana, 2025), as well as international studies emphasizing the importance of linking academic knowledge with learners' everyday environments (Ann et al., 2024; Suh & Calabrese, 2025). However, this study extends prior research by positioning architectural ethnomathematics as a particularly powerful context. Unlike many Indonesian studies that focus on surface-level cultural artifacts, including batik motifs or traditional games, this research demonstrates that architectural elements such as rectangles, triangles, and prisms embedded in the Joglo Jompongan structure embody abstract mathematical relationships in a structurally coherent and conceptually rich manner. (Ja'faruddin & Naufal, 2023; Pradana et al., 2022; Shahbari & Daher, 2020).

From a pedagogical perspective, the findings suggest that teacher professional development should emphasize systematic identification and didactical transformation of local cultural contexts using culturally responsive and ethnomathematical frameworks (Ann et al., 2024). At the curriculum level, these results support the integration of culturally grounded instructional resources to bridge formal mathematical concepts with students' familiar cultural environments, reinforcing both conceptual learning and cultural identity (Gbormittah et al., 2025; Jacob et al., 2023; Munthahana et al., 2023; Murti, 2023).

Despite these contributions, this research has several limitations. The study involved a relatively small sample from a single learning center, which may limit the generalizability of the findings. In addition, the intervention was implemented over a short duration, making it difficult to assess long-term impacts on conceptual retention and transfer. The focus on a single cultural artifact the *Joglo Jompongan* also constrains the scope of cultural comparison. Future research should therefore apply the CReM model to diverse cultural contexts, such as *Toraja* or *Gadang* houses, traditional crafts, or indigenous knowledge systems, and explore digital or immersive representations (e.g., augmented reality simulations) to further enhance spatial reasoning and examine sustained learning outcomes. Overall, this study contributes to ethnomathematics and culturally responsive pedagogy by demonstrating that architectural contexts are not merely illustrative tools but function as conceptual mediators that support visualization, embodiment, and cultural meaning-making in mathematics learning.

Conclusion

The Culturally Responsive–Ethnomathematics (CReM) model grounded in the *Joglo Jompongan* architectural context meaningfully supports students' numeracy literacy, geometry understanding, and cultural awareness at the junior high school level. Rather than positioning culture as a supplementary illustration, this research demonstrates that architectural heritage can function as a conceptual scaffold through which abstract geometric ideas—such as area, perimeter, volume, and proportion are organized, visualized, and understood. In this regard, the study contributes theoretically to Culturally Responsive Teaching (CRT) and ethnomathematics by emphasizing culture as an epistemic resource that shapes mathematical meaning-making, not merely as a contextual backdrop.

From a practical standpoint, the findings indicate that the CReM model provides teachers with a structured approach to translating local cultural artifacts into coherent learning designs that promote conceptual understanding and student engagement. The development of culturally grounded Student Activity Sheets and teacher guides illustrates how curriculum materials can be designed to integrate mathematical reasoning, spatial visualization, and cultural reflection in a systematic manner. For curriculum developers, this study highlights the potential of embedding architectural and spatial cultural contexts within geometry curricula to strengthen the relevance and inclusivity of mathematics learning, particularly in diverse or non-formal education settings.

In terms of future research, further studies are encouraged to apply the CReM model across different cultural architectures and educational contexts to enhance cross-cultural and international comparability. Exploring digital and immersive representations of cultural buildings such as virtual or augmented reality may also extend the model's applicability and provide deeper insights into spatial reasoning and culturally responsive mathematics learning in global contexts.

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Declarations

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