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Ethnomathematics Exploration of the Architecture of the At-Taqwa Grand Mosque in Southeast Aceh

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Abstract

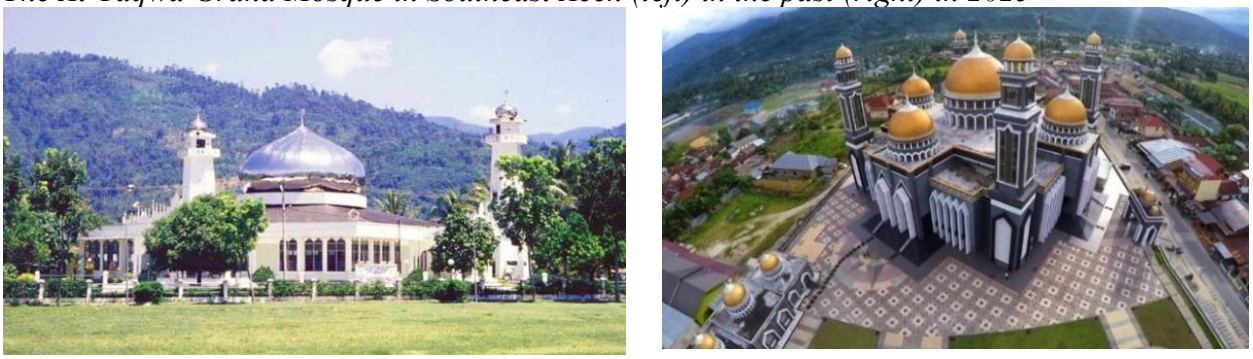
This study examines the application of ethnomathematics in the architecture of the At-Taqwa Grand Mosque in Southeast Aceh, which combines Eastern European style with local Alas culture. Previous ethnomathematics studies in Indonesia have generally focused on traditional houses, folk games, or mosques in other regions but have not linked geometric forms with cultural values and contextual education. These gaps form the basis of this study to explore the relationship between mathematics, culture, and education. The study aims to identify geometric concepts in mosque architecture and explain their cultural significance and potential application in mathematics learning based on local wisdom. Its novelty lies in the in-depth exploration of mosque ornaments as a medium integrating art, culture, and mathematics. The method used is qualitative with an ethnographic approach. Data were collected through observation, interviews with traditional leaders and mosque administrators, and documentation. Data analysis followed the Miles and Huberman model, including data reduction, presentation, and verification through source triangulation. The findings reveal that the At-Taqwa Grand Mosque architecture contains concepts of flat shapes (triangles, squares, circles), solid shapes (blocks, prisms, hemispheres), and geometric transformations (translation, reflection, rotation, dilation). These elements are not only aesthetically valuable but also reflect the mathematical order and cultural philosophy of the Alas people. Thus, the mosque's architecture represents the integration of art, culture, and mathematics and serves as a potential source for contextual learning in mathematics education.

Keywords: ethnomathematics, Agung At-Taqwa Mosque, Alas culture.

1. Introduction

The Agung At-Taqwa Mosque in Kutacane, Southeast Aceh, is one of the grandest mosques built with a blend of Eastern European architectural styles and local cultural touches that remain in harmony with Islamic principles. As a center of religious and socio-cultural activities for the community, this mosque not only functions as a place of worship but also as a symbol of the identity and local wisdom of the people of Southeast Aceh. The changing times demand mosque architecture that is functional while also representing local culture and ethnomathematics (Jainuri et al., 2025); (Putra et al., 2021); (Tolla & Khaerani, 2024). The At-Taqwa Grand Mosque can thus be seen as a tangible manifestation of the fusion between local culture and modernization, as well as a medium for preserving community identity amid the tide of globalization.

Figure 1.
The At-Taqwa Grand Mosque in Southeast Aceh (left) in the past (right) in 2025



Ethnomathematics, as stated by D'Ambrosio (1985), places mathematics as a cultural product that is integrated into the social practices of society (Risdiyanti & Prahmana, 2021). In Indonesia, a number of studies have shown that mathematical principles are present in various cultural artifacts such as traditional houses, traditional games, and local arts (Maysarah et al., 2025)**;** (Hasibuan & Hasanah, 2022); (Sinulingga et al., 2025). However, the focus of research is generally still limited to descriptive aspects of form and pattern without exploring the underlying cultural meaning or pedagogical relevance for culture-based mathematics learning. In this context, ethnomathematics studies are important to bridge the gap between cultural understanding and formal education, particularly in relating architectural structures to the mathematical values contained within them.

Table 1.
Relevant research

No	Relevant research	Contribution to Research	Limitations of the research
1.	Jurnal (Aflah et al., 2022) under the tittle "Etnomatematika	Provides a conceptual basis for understanding	Does not discuss the application of these

	dalam Budaya Suku Alas di Kabupaten Aceh Tenggara*"*	mathematical values in Alas culture that can be linked to the architecture of the At-Taqwa Grand Mosque.	concepts in religious architecture, particularly mosques.
2.	Jurnal (Alvianto & Setianingsih, 2024), under the tittle *"*Eksplorasi Etnomatematika Pada Peninggalan Sejarah Dan Budaya Sumenep*"*	Inspires an exploratory methodological approach to examining the relationship between architecture and mathematics learning.	Limited geographical focus; does not relate the results to contextual mathematics education.
3.	Jurnal (Taqiuddin et al., 2024) under the tittle *"*Etnomatematika dalam Perancangan Arsitektur Masjid: Integrasi Seni Geometri Islami dalam Arsitektur Masjid Harun Keuchik Leumik Banda Aceh*"*	Serves as a comparison in viewing the integration of religious architectural styles with distinctive local cultural elements in Southeast Aceh.	Does not examine the influence of non-Islamic local cultures (such as Alas culture) on architecture.
4.	Jurnal (Jamalul Lail et al., 2021) under the tittle *"*Eksplorasi Etnomatematika dan Filosofi Nilai-Nilai Islam Pada Masjid Agung Kauman Semarang*"*	Provides an analytical reference for connecting cultural philosophy with application.	Does not extend the analysis to aspects of culture-based mathematics education.

Several previous studies, such as those conducted on the Harun Keuchik Leumik Mosque in Banda Aceh (Taqiuddin et al., 2024) and the Kauman Grand Mosque in Semarang (Jamalul Lail et al., 2021), have explored the integration of Islamic geometric art in religious architecture. Meanwhile, a study of Alas culture (Aflah et al., 2022) identified mathematical concepts in the lives of local communities, but did not directly link them to monumental architecture such as the At-Taqwa Grand Mosque. Thus, there is still a gap in research in understanding how local cultural values influence the geometric construction of mosque architecture and how these elements can be utilized in contextual mathematics learning.

However, most previous studies are still descriptive and limited to identifying geometric forms without examining the underlying cultural meanings or their implications for culture-based mathematics education. In addition, no research has specifically highlighted the At-Taqwa Grand Mosque in Southeast Aceh as an object of ethnomathematics study, even though this building has a unique architecture that combines elements of Alas culture and Islamic modernity. This gap indicates the need for studies that integrate architectural aspects, cultural values, and mathematical

concepts within a more interpretive and applicable ethnomathematics framework (Faturrahman & Soro, 2021); (Susanti & Budiarto, 2020).

By focusing the study on the concept of ethnomathematics in the architecture of the At-Taqwa Grand Mosque in Southeast Aceh, this research aims to explore and analyze the concept of ethnomathematics in the architecture and ornamentation of the At-Taqwa Grand Mosque in Southeast Aceh, as well as examine its potential application in mathematics learning based on local culture. The novelty of this research lies in its approach, which not only maps geometric shapes but also interprets the cultural values of the Alas people embedded in the architecture of the mosque and relates them to the development of contextual mathematics learning. Thus, the results of this study are expected to increase the awareness of the people of Southeast Aceh of the cultural values in the architecture of their mosque, as well as inspire further studies on ethnomathematics and architecture in various other cultural contexts in Indonesia.

2. Methods

This study uses a qualitative method with an ethnographic approach because it is able to deeply explore the cultural meanings contained in mosque architecture and relate them to the concept of ethnomathematics (Setiyadi & Muttaqin, 2024); (Dhiki & Bantas, 2021). This approach provides space for researchers to understand cultural phenomena holistically through direct interaction with the environment and cultural actors in the field. The research was conducted at the At-Taqwa Grand Mosque, located in Pulo Sanggar, Babussalam District, Southeast Aceh Regency, with a focus on identifying mathematical concepts reflected in mosque ornaments and on the implementation of ethnomathematics values that can be integrated into local culture-based learning.

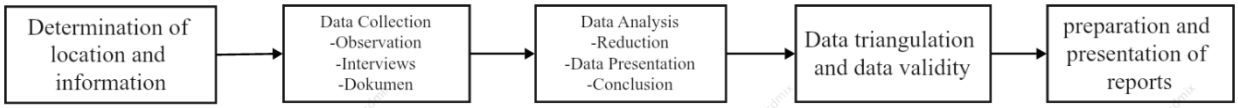
Research informants were selected purposively, considering their level of knowledge, experience, and direct involvement in the preservation of Alas culture and mosque management. There were two main informants, consisting of the head of the At-Taqwa Grand Mosque Technical Implementation Unit (UPTD) and a traditional leader of the Alas tribe. The head of the mosque UPTD served as a source of information related to the history of the mosque's construction, architectural philosophy, and the symbolism of the mosque's space, while the traditional leader of the Alas tribe explained the philosophical meaning and cultural values reflected in the ornaments. This diversity of roles enabled the study to obtain a comprehensive view of three main domains, namely culture, religious architecture, and education.

The data in this study were collected through three main techniques, namely direct observation, in-depth interviews, and documentation studies (Ulfatin, 2022). Observations were conducted to identify mathematical elements in the ornaments and architectural forms of the mosque, such as symmetry, rotation, transformation, and proportion; interviews were conducted with the head of the UPTD Mosque and traditional Alas leaders to explore the cultural and philosophical meanings of the ornaments; while documentation studies were used to examine archives, literature, and relevant documents. Data analysis followed the model of Miles, Huberman, and Saldana (1994), which included three stages, namely data reduction by sorting and summarizing according to the research theme, presenting data in a descriptive narrative form, and

drawing conclusions through verification of the relationship between ethnomathematics and mosque architecture with data triangulation (Rachman et al., 2024).

Overall, this research process was carried out systematically as illustrated in the following research flowchart, which includes the stages of determining the location and informants, collecting data through observation, interviews, and documentation, followed by data analysis, triangulation and validation, and finally the stage of interpretation and preparation of the research report.

Figure 2.
Flowchart research process



3. Result and Discussion

3.1 History of the At-Taqwa Grand Mosque in Southeast Aceh

On December 6, 1957, sixty community leaders from Tanah Alas and Gayo Lues gathered at MIN Perapat Hulu (now MIN 1 Southeast Aceh) to discuss plans for regional expansion. At the meeting, they demanded that Tanah Alas and Gayo Lues be separated from Central Aceh if the capital was not moved to Kutacane. This movement was halted in 1959 after the death of Tgk. Syamsudin, the leader of the movement. However, the spirit of struggle was revived thanks to the support of the Military Command Sector VII under the leadership of Captain M. Amien and Lieutenant Syahadat. From this spirit, the idea of building a grand mosque as a center for Islamic preaching and a symbol of community unity was born.

A construction meeting was held at the Community Hall, which is now the Kodim 0108 Office. At the meeting, it was agreed that the mosque would be built on swamp land. H. M. Yusuf Simatupang or Uan Morang sincerely donated 5,000 m² of land for this purpose. In 1961, a construction committee was formed and the mosque was named At-Taqwa Grand Mosque. The construction was financed through community donations, infaq, alms, and rice exports from the region, and was carried out through mutual cooperation. Despite limited funds, in early 1962 a simple mosque was successfully built with wooden walls, a tin roof, and a cement floor.

Since then, the At-Taqwa Grand Mosque has become the center of religious and social activities for the people of Southeast Aceh. Tgk. M. Yunus was appointed as the first nazir, while the grand imam was Tgk. H. Sedar from Telaga Mekar. Over time, the mosque underwent several major renovations in 1981, 1984, 1994–1995, and 2009–2010. The 2016 renovation was an important milestone because it demonstrated the community's concern for the preservation of local culture. The mosque's architecture is decorated with various Alas ornaments that are rich in philosophical meaning. The pucuk khebung ornament symbolizes the spirit of progress, embun bekhangket depicts the cycle of life, tampuk gete represents wisdom in facing changing times, while bunge jambu symbolizes purity and balance in life. Thus, the At-Taqwa Grand Mosque not

only functions as a place of worship but also serves as a symbol of struggle, unity, and the cultural identity of the Southeast Aceh community, passed down from generation to generation.

3.2 Ethnomathematical Elements in the Architecture of the At-Taqwa Grand Mosque in Southeast Aceh

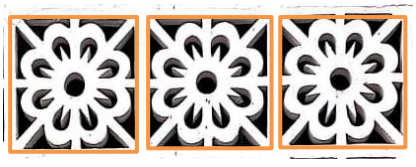
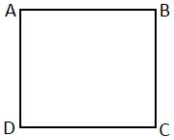
This research was conducted at the At-Taqwa Grand Mosque in Southeast Aceh, focusing primarily on the architecture of the mosque. The research data was obtained through interviews with traditional leaders, mosque administrators, and mathematics teachers, and was reinforced by direct observation and visual documentation in the field. From the results of the data collection, it was found that each ornament not only functions as a decoration or aesthetic element, but also has a philosophical meaning related to the culture of the Alas people.

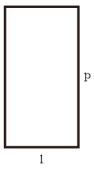
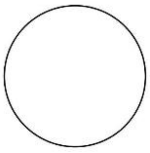
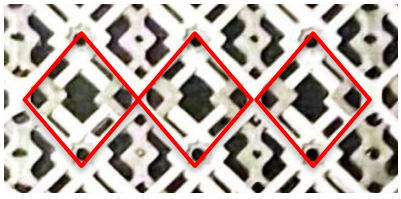
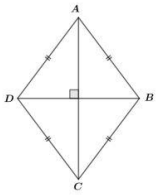
Thus, the results of this study show that the ornaments of the At-Taqwa Grand Mosque are a manifestation of the integration of art, culture, and science, especially mathematics. The following is a description of the main ornaments found in the mosque along with their cultural meanings and mathematical concepts contained therein:

3.2.1 Flat Shapes in the At-Taqwa Mosque in Southeast Aceh

Various flat shapes were found in the ornaments of the At-Taqwa Grand Mosque in Southeast Aceh, which form the basis for the decorative patterns. These geometric shapes appear either individually or in combination, resulting in a variety of motifs that are not only beautiful to look at but also have mathematical value Triangles, squares, rectangles, rhombuses, and ellipses are clearly visible in the structure of the ornaments, which are arranged in a regular and repetitive manner. This shows that the architectural art and culture of the Alas people are closely related to geometric concepts, particularly in the use of flat shapes to create harmonious and meaningful patterns.

Table 2.
Flat Shape Elements of the At-Taqwa Mosque in Southeast Aceh.

No.	Ethnomathematics	Mathematical Concept
1.		 Possesses 3 sides of equal length, has 3 angels of equal size, namely 60° Area $= \frac{1}{2} \times a \times t$, Perimeter $= 3 \times$ side , height $= (2 \times L) \div a$, Based$= (2 \times L) \div t$
2.		 A square has 4 sides of equal length ang 4 right angels. Area $= s \times s$ Perimeter $= 4 \times s$

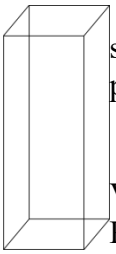
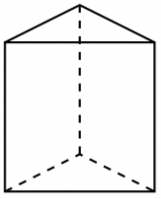
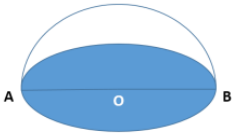
3.			a rectangle has 2 sides of equal length ang 4 right angels of 90° Area $= \mathrm{p} \times \mathrm{l}$ Perimeter $= 2 \times (p + l)$
4.			a circle is a flat shape that has 1 closed curved side. Area $= \pi \times \mathrm{r}^2$, Perimeter $= 2 \times \pi \times \mathrm{r}$, Diameter $= 2\mathrm{r}$
5.			a rhombus has 4 sides of equal length, with 2 pairs of opposite angels of equal size. Area $= \frac{1}{2} \times \mathrm{d}_1 \times \mathrm{d}_2$, Perimeter $= 4\mathrm{s}$ Side $= \frac{1}{2}\sqrt{\mathrm{d}_1 + \mathrm{d}_2}$

Thus, it can be seen that the ornaments of the At-Taqwa Grand Mosque in Southeast Aceh contain various flat shapes. The existence of these shapes not only beautifies the appearance of the mosque's architecture but also shows the application of geometric concepts in culture After identifying the flat shapes, the next step is to analyze the geometric transformations found in the ornament patter.

3.2.2 Spatial Elements in the At-Taqwa Mosque in Southeast Aceh

After identifying the flat shapes, this study also found architectural elements of the At-Taqwa Grand Mosque that represent spatial shapes. Elements such as domes, minarets, and pillars. demonstrate the application of three-dimensional geometric concepts, such as spheres. cylinders, pyramids, and prisms. These shapes not only serve a structural function but also represent symbolic meanings in the culture and religion of the people of Southeast Aceh. The identification of spatial elements in mosque architecture is shown in the following table.

Table 3.
Spatial Elements in the At-Taqwa Mosque in Southeast Aceh

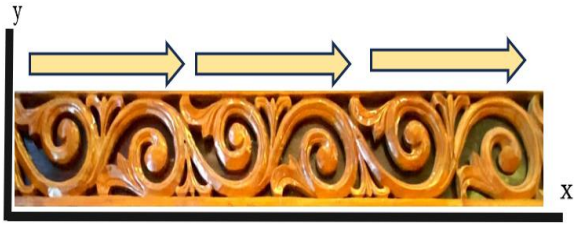
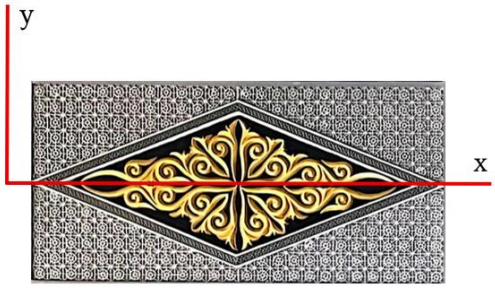
No.	Ethnomathematics	Mathematical Concepts
1.		 A block has 6 rectangular sides, 12 edges and 8 vertices. Each parallel edge has the same length. Volume $= p \times l \times t$ Perimeter $= 4 \times (p + l + t)$ Surface area $= 2\,(pl + pt + lt)$
2.		 A triangular prism has a triangular base and roof and three rectangular sides. Volume = $B \times h$ Surface Area = $2B + hP$
3.		 A hemisphere is a half of a sphere that has one curved surface and one flat surface Volume $= \frac{2}{3} \times \pi \times r^3$ Surface Area $= 3 \times \pi \times r^2$

3.2.3 Geometric Transformation Elements of the At-Taqwa Mosque in Southeast Aceh

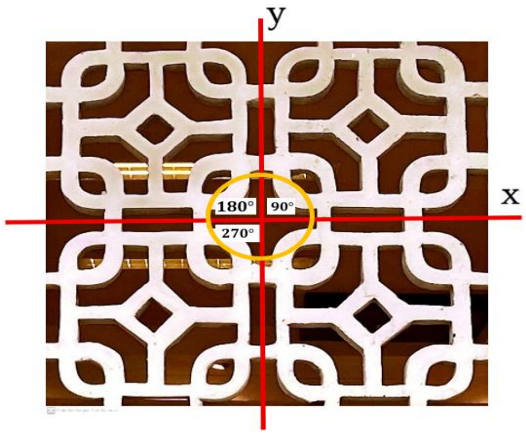
The architecture of the At-Taqwa Grand Mosque in Southeast Aceh not only features flat and spatial elements, but also showcases the application of geometric transformation concepts that are characteristic of Islamic architecture. The regularly repeated ornamental patterns based on the principles of rotation, reflection, translation, and dilation create a balance and visual harmony that is rich in spiritual meaning. Motifs such as stars, flowers, and diamond shapes demonstrate mathematical regularity while symbolizing the perfection of God's creation. In addition to its aesthetic value, the application of geometric transformations also has educational value because it shows the integration of culture, art, and mathematics. Thus, the At-Taqwa Grand Mosque is not only a symbol of the beauty of Islamic architecture, but can also be used as a medium for contextual learning in ethnomathematics-based mathematics education.

Tabel 4.

Elements of Geometrics Transformation in the At-Taqwa Mosque in Southeast Aceh

No.	Ethnomathematics of Geometrics Transformation.	Mathematical Concept
1.		Translation is the movement of a shape without changing its shape or size. formula: $T(x,y) \xrightarrow{(a,b)} T'(x+a, y+b)$
2.		Reflection is the image of a shape with respect to a certain. formula: reflection with respect sb x $R(x,y) \xrightarrow{\text{sb x}} R'(x,-y)$

3.



Rotation is the turning of a shape around a center point by a certain angel.
Formula:

$$(x, y) \xrightarrow{\{O,90^\circ\}} (-x, y)$$
$$(x, y) \xrightarrow{\{O,180^\circ\}} (-x, -y)$$
$$(x, y) \xrightarrow{\{O,270^\circ\}} (y, -x)$$

4.

Dilatation is a change in size (enlarging or reducing) by a certain ratio from the center point.
formula:

$$(x, y) \xrightarrow{D\{O,k\}} (kx, ky)$$

Thus, this study not only reveals the existence of mathematical elements in the ornaments of the At-Taqwa Grand Mosque in Southeast Aceh, hut also contributes to the development of culture-based mathematics learning.

3.3 Discussion

The results of the study show that the ornaments of the At-Taqwa Grand Mosque in Southeast Aceh contain various mathematical concepts reflected in flat shapes, spatial shapes, and geometric transformations. These three concepts are interrelated and form a unity of aesthetics and philosophical meaning in the architecture of the mosque. The concept of flat shapes is dominant in the exterior and interior ornaments of the mosque through the harmonious arrangement of triangles, squares, rectangles, rhombuses, and circles. These shapes show that geometry is not only abstract but also present in everyday life. For example, the triangular shape at the top of the entrance reflects the principle of an isosceles triangle, while rectangular windows and doors can be used as a medium to understand the nature of quadrilaterals. In addition, the element of spatial construction reinforces the spatial dimension of the mosque, as seen in the block-shaped pillars, triangular prism elements

around the pulpit, and the hemispherical dome that is the icon of the building. The presence of these three-dimensional shapes displays visual beauty and spatial balance that reflect the value of harmony in Islamic teachings.

Furthermore, the relationship between flat and spatial shapes is enriched through the application of geometric transformations that give dynamism to the mosque's architectural patterns. These transformations are evident in the repetition of motifs, symmetry, and variations in the size of the ornaments. Translation is seen in the diamond and lattice flower patterns, reflection is seen in the folded symmetry of the ornaments and triangular motifs on the dome, rotation appears in the arrangement of the centered flowers and stars, while dilation is illustrated through the differences in the sizes of the domes, which remain proportional. The integration of these three concepts shows that mathematics, art, and culture complement each other in creating meaningful architecture. In line with D'Ambrosio's (1985) view, mathematics is a cultural activity that lives within society. Therefore, the ornaments of the At-Taqwa Grand Mosque can be used as a source of contextual learning in mathematics education to help students understand geometric concepts concretely, while fostering an appreciation of the aesthetic, cultural, and spiritual values of Southeast Aceh.

4. Conclusion

4.1 Major Findings

This study found that the architecture and ornamentation of the At-Taqwa Grand Mosque in Southeast Aceh contain various ethnomathematical elements, including flat shapes (triangles, squares, rectangles, rhombuses, circles, ellipses), three-dimensional shapes (blocks, triangular prisms, and ellipses), and geometric transformations (translations, reflections, rotations, and dilations). The existence of these elements shows that the architecture and ornamentation of the At-Taqwa Grand Mosque in Southeast Aceh are not only aesthetically valuable but also reflect order and mathematical principles relevant to the concept of geometry and reflect the cultural philosophy of Alas.

4.2 Educational Implications

These findings confirm that ethnomathematics is present in society's culture and can be used as a source of contextual learning in mathematics education. By integrating local cultural elements into learning, students not only understand mathematical concepts conceptually but also develop an appreciation for cultural heritage and local wisdom, making learning more meaningful and contextual.

4.3 Recommendations for Further Research

Further research is recommended to develop an ethnomathematics-based learning model that uses the architecture of the At-Taqwa Grand Mosque as a concrete medium. In addition, comparative studies with mosques in other regions are also important to broaden understanding of the diversity of ethnomathematics expressions in Indonesia and to explore their contribution to the development of a mathematics curriculum based on local culture.

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