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Exploration of Mathematical Patterns in Traditional Cang Kuning Food in Sulawesi

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ABSTRACT

Purpose of the study: The purpose of this study is to explore ethnomathematics elements in traditional Cang Kuning food, especially in the concept of geometry and its presentation patterns, and to integrate Cang Kuning as a contextual and relevant mathematics learning medium for students' lives.

Methodology: This study uses a qualitative approach with an ethnographic research type. The tools used include interview sheets, observation sheets, and visual documentation. Data collection methods consist of participant observation and in-depth interviews. A literature review was conducted to support the analysis, while the software used for data analysis was NVivo.

Main Findings: This study shows that Cang Kuning cake contains various mathematical concepts, including comparison, similarity, and spatial shapes. The process of making the cake reflects the application of geometry in its design and presentation. This cake also has significant cultural value, reflecting the philosophy of the Bugis people and has the potential as a contextual mathematics learning medium.

Novelty/Originality of this study: The novelty of this research lies in the exploration of ethnomathematics in traditional Cang Kuning food, which has not been widely studied before. This research develops knowledge about the integration of culture and mathematics, and shows the importance of cultural context in mathematics learning. This provides new insights for educators to create more relevant and interesting learning methods for students.

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1. INTRODUCTION

Mathematics is often viewed as an abstract, difficult, and irrelevant discipline to everyday life. This view causes students to lose interest in learning mathematics because they feel that the concepts taught are not directly related to their everyday experiences. Research shows that this negative perception largely stems from the idea that mathematics consists only of formulas, numbers, and theories that are separate from wider culture and social life [1]. When students view mathematics as an isolated subject and detached from the context of the real world, they tend to find it difficult to apply mathematical knowledge in everyday life, which in turn causes their low motivation to learn [2]. This is exacerbated by the lack of attention to the social and cultural context in the mathematics learning process, which actually plays an important role in increasing students' understanding and interest [3].

The decline in motivation and understanding in learning mathematics can be overcome by connecting mathematical concepts to real-life contexts that are closer to students' experiences. One way to do this is by integrating local culture into mathematics learning. Several studies have suggested that a culture-based approach can improve students' understanding and interest in mathematics. For example, Wahyudin [2] explained that mathematics is often considered a subject that is not related to local culture, which leads to a lack of interest and motivation in learning it. Therefore, mathematics learning that is relevant to local culture can be an effective solution in bridging the gap between abstract mathematical concepts and students' real experiences [4]. One approach that can be used to connect mathematics to local culture is ethnomathematics. The concept of ethnomathematics was first introduced by Ubiratan D'Ambrosio in the 1980s, who emphasized the importance of understanding how mathematics is used in the social and cultural life of a society. Ethnomathematics not only teaches mathematical concepts through a local cultural perspective, but also explores the ways in which traditional communities use mathematics to solve their daily problems [5]. This approach provides insight that mathematics does not only function as a set of abstract formulas, but also as a tool used in various cultural practices and social life. By utilizing ethnomathematics, students can learn mathematics in a context that is closer to their culture, making learning more relevant, contextual, and interesting [6].

In education, ethnomathematics approaches have been shown to provide many benefits, such as improving students' understanding of complex mathematical concepts and introducing them to the cultural values that exist in their society. In this context, culture-based mathematics learning provides students with a richer and more meaningful learning experience, allowing them to more easily understand concepts that are often considered abstract, such as geometry, comparison, and statistics, by directly linking them to cultural elements that they know and experience every day [7]. For example, traditional foods such as Cang Kuning from South Sulawesi have many mathematical elements contained in their form and manufacturing process. Cang Kuning is a typical Bugis food made from sticky rice and grated coconut. The process of making this food contains mathematical patterns that can be explained with concepts such as symmetry, comparison, and geometry [8]. Using traditional foods such as Cang Kuning as a medium for learning mathematics allows students to understand mathematical concepts in a more enjoyable, contextual, and relevant way to their lives.

In mathematics learning, the use of Cang Kuning as a medium to teach mathematical concepts provides enormous added value. This traditional food not only reflects the richness of a particular regional culture, but also serves as a real example of the application of mathematics in everyday life. For example, making Cang Kuning involves dividing the dough proportionally to produce symmetrical shapes, which illustrate mathematical concepts such as comparison and similarity [9]. In addition, the geometric patterns found in the Cang Kuning shapes provide real examples of geometry and symmetry in everyday life that can be more easily understood by students compared to more abstract concepts in textbooks.

Based on this phenomenon, this study aims to explore the application of ethnomathematics in mathematics learning by using traditional Cang Kuning food as a medium for teaching mathematical concepts. Although ethnomathematics has been applied in various cultural contexts, most previous studies have focused more on larger and more general cultural objects, such as music, art, or architecture [10]. Most ethnomathematics research focuses on architecture, music, art, and there has not been much exploration of traditional foods such as Cang Kuning. This study innovates by exploring the potential of local culture that is more specific and more directly related to students' daily lives, namely traditional food that not only contains high cultural value, but also has mathematical elements that can be taught in mathematics learning [11]. This approach provides a new contribution to ethnomathematics research, by highlighting the important role of traditional food as a means to teach mathematical concepts directly and enjoyably for students.

The innovation proposed in this study lies in the application of a more specific ethnomathematics approach, focusing on traditional foods that can be directly related to students' daily lives. Previously, although the concept of ethnomathematics has been used for various cultural practices, this study attempts to explore the potential of local cultures that are closer and more understandable to students. By using Cang Kuning as an example, this study aims to show how traditional foods can be a means to explain mathematical concepts such as geometry, similarity, and comparison in a more contextual and interesting way. This approach is expected to help students not only understand mathematics, but also develop an appreciation for the richness of their local culture, which is important in maintaining and preserving local wisdom amidst the increasingly strong current of globalization [12]. The difference with previous studies is that this study uses visual documentation (photos/YouTube videos) and direct geometric analysis.

Thus, this study aims to develop mathematics learning that is not only abstract, but also connected to students' real experiences through a more contextual and relevant approach. The purpose of the study is to explore mathematical elements in Cang Kuning food as a learning medium. The novelty of this article is raising traditional food as a medium for teaching mathematics, not just general culture. By connecting mathematical concepts with students' daily lives and local culture, it is hoped that students will find it easier to understand mathematical concepts that were previously considered difficult and abstract. This study is important because

students need a mathematics learning approach that is relevant to real life. As a result, mathematics learning will be more interesting, meaningful, and can increase students' motivation to learn [13].

2. RESEARCH METHOD

This study uses a qualitative approach with an ethnographic research design. This approach was chosen because it allows researchers to understand and describe cultural phenomena related to ethnomathematics in traditional Cang Kuning food from Sulawesi. The ethnographic research model refers to the Spradley framework, which involves six stages: selecting an ethnographic project, formulating ethnographic questions, collecting data, recording data, analyzing data using domain and taxonomic analysis, and compiling a final report [14], [15]. These stages are carried out systematically to ensure that the data obtained can clearly describe the relationship between culture and mathematical concepts. Data collection was carried out through three main methods: participant observation, where researchers participated in the process of making Cang Kuning; in-depth interviews with three informants who have expertise in making this cake; and visual documentation, in the form of photos and videos that record the entire cake-making process. Research instruments include interview sheets, field notes, and supporting media such as cameras for documentation [16]. Where the instruments and data collection techniques are interviews, observations, visual documentation.

The collected data were analyzed qualitatively using domain analysis methods to identify cultural patterns related to geometry and mathematical concepts. This process involved grouping data based on themes, such as the concept of comparison in the mixture of cake ingredients, the concept of similarity in the wrapping leaves, and the concept of spatial shapes in the final shape of the cake which resembles a square pyramid [17]. The analysis was carried out in depth to ensure that the relationship between cultural elements and mathematical concepts was clearly identified. This study also used triangulation techniques to increase the validity of the data, by comparing the results of interviews, observations, and visual documentation. For example, the concept of comparison in the mixture of cake ingredients was verified through interviews with informants and direct observation during the making process. The findings of this study support the view that traditional food can be a relevant learning medium for teaching mathematical concepts contextually. This is in line with previous studies showing that the integration of local culture into mathematics learning can increase the relevance of the material and students' learning motivation [18], [19].

The results of this study indicate that ethnographic methods can be used to explore the relationship between mathematics and local culture, thus contributing to the development of innovative and contextual learning media. By understanding mathematical patterns in cultural traditions such as Cang Kuning, students not only learn abstract concepts but also gain a broader understanding of the cultural values and traditions of their society [18].

3. RESULTS AND DISCUSSION

To enrich the analysis of this study, in-depth interviews were conducted with three sources who are experts in making traditional Cang Kuning food. This interview aims to identify cultural elements and mathematical concepts contained in the process of making Cang Kuning. A summary of the interview results is presented in Table 1 below.

Table 1. Interview Results

Aspect	Summary
History and origin	Cang Kuning Cake has been around since the time of our ancestors, made for traditional events, and symbolizes a life full of blessings.
The meaning of cake in Bugis society	White symbolizes purity, purple symbolizes nobility, and brown sugar symbolizes happiness and blessings.
Traditions and events When is Cang Kuning cake served?	Cakes are prepared for big events such as weddings, the Prophet's Birthday, or thanksgiving as a symbol of respect and gratitude.
Cultural values taught	Served after the main course or given to guests as a treat or souvenir.
Symbols or special meanings in the form of cakes	Teaches patience, togetherness, and respect for tradition and the value of mutual cooperation in the process of making it.

Based on interviews with three sources who are Bugis community leaders experienced in making Cang Kuning cake, it was concluded that this cake has a deep symbolic meaning in Bugis culture. The sources agreed that Cang Kuning, although made from simple ingredients, contains a philosophy and life values that are very important for the Bugis community. The white layer on the cake symbolizes purity and sincerity, while the

purple layer represents nobility, strength, and courage. The brown sugar in it is not only a sweetener, but symbolizes happiness, blessings, and hopes for a sweet and blessed life [20].

Cang Kuning making is often done in important moments of Bugis society, such as weddings, traditional events, and thanksgiving. The making process teaches cultural values such as patience, precision, mutual cooperation, and togetherness. These values are reflected in the way Cang Kuning is made which involves family members and neighbors, which then strengthens social relationships and strengthens the sense of togetherness in the community [12]. This concept is in line with research conducted by Wulandari [12]. which states that learning based on local culture provides a deeper understanding of the social and cultural values of a society, which can then enrich students' learning experiences.

In addition to the cultural value contained in the making of Cang Kuning, this traditional food also contains various mathematical elements related to the shape and structure of the cake. For example, the geometric patterns that appear when the dough is formed can be connected to the concepts of symmetry, comparison, and geometry. Dough that is divided into equal parts, both in terms of the proportion of ingredients and the uniform shape of the cake, reflects basic concepts in mathematics. The process of making Cang Kuning which involves dividing the dough proportionally illustrates the principle of ratio in mathematics, while the symmetrical shapes created during the making process can be explained using the concepts of similarity and geometric transformation [6], [2].

This approach shows how ethnomathematics can be used to connect mathematical concepts with local culture. Cang Kuning as a learning medium allows students to not only learn abstract mathematical formulas, but also to relate these concepts to their real daily experiences, especially in their cultural context. For example, the symmetrical patterns found in Cang Kuning can be used to teach reflection or rotational symmetry, which are basic concepts in geometry [6]. This supports previous findings by Putra [21], who stated that teaching mathematics using local cultural elements can increase students' interest and understanding of the material being taught. In addition, the symbolism and philosophy contained in Cang Kuning provide a deeper context for teaching mathematics. Wahyudin [2], stated that ethnomathematics does not only introduce mathematical concepts, but also introduces the values of life that exist in local culture. Thus, using Cang Kuning as a learning medium not only teaches mathematical concepts, but also enriches students' understanding of the culture and values of life contained in their society.

Overall, Cang Kuning is not just a traditional food, but also full of deep symbolism and philosophy that reflects the hope for happiness, prosperity, and a blessed life. In addition, Cang Kuning is also an excellent example of applying the ethnomathematics approach, which not only helps students understand mathematics through a cultural context that is closer to their lives, but also connects mathematical concepts with cultural practices that are very relevant to their daily lives [4], [12], [21].

3.1. Comparison Concept

Based on the results of the study through observation, the comparison concept was found in the process of making Cang Kuning cake. From the video analysis, it is known that the making of this cake begins with making two types of layers: a white outer layer and a black inner layer. Both layers are made using a mixture of various types of flour with certain measurements, as seen in Figure 1. If explored further, the measurement of the flour mixture used in making this cake layer reflects the application of the comparison concept.

Figure 1. Inner layer of yellow cang cake
Source: https://youtu.be/ZEugHFsw4Z0?si=8TvixAF4u90QukfN

Figure 2. Outer layer of yellow cang cake
Source: https://youtu.be/ZEugHFsw4Z0?si=8TvixAF4u90QukfN

The first layer is black in color and serves as a wrapper for the Cang Kuning cake filling. This layer is made from a mixture of black glutinous rice and white glutinous rice that has been mashed. Based on interviews, it is known that the measurement of black and white glutinous rice has a ratio of 2: 1. If the amount of black glutinous rice is referred to as A and the amount of white glutinous rice as B, then the proportion of both can be clearly stated in the ratio.

$$A : B = 2 : 1$$

$$\frac{A}{B} = \frac{2}{1}$$

For the second layer which is white, the dough is made from a mixture of regular rice flour and wheat flour. This white layer will later be used as the outermost layer of Cangkuning cake. Interestingly, the concept of comparison is also found in this cake layer.

3.2. Concept of similarity

The concept of similarity is found in the process of making Cang Kuning cake. Based on interviews and observations, it is known that two types of leaves are used in making it, namely older leaves and younger leaves. The leaves are cut into several parts, where the older leaves function as a coating for the younger leaves. The size of the wrapping leaves varies depending on availability, but the interesting thing is that the size of the outer wrapping leaves is always larger than the inner wrapping leaves. Both types of leaves have the same shape, namely rectangular, as shown in Figure 3.

Figure 3. Banana leaf wrapper for similarity shaped cake
Source: https://youtu.be/ZEugHFsw4Z0?si=8TvixAF4u90QukfN

The wrapping leaf, if observed, has a geometric concept in the form of similarity. Two shapes are said to be similar if their angles are the same and their corresponding sides also have the same ratio. This concept can be described in geometric form as seen in Figure 4.

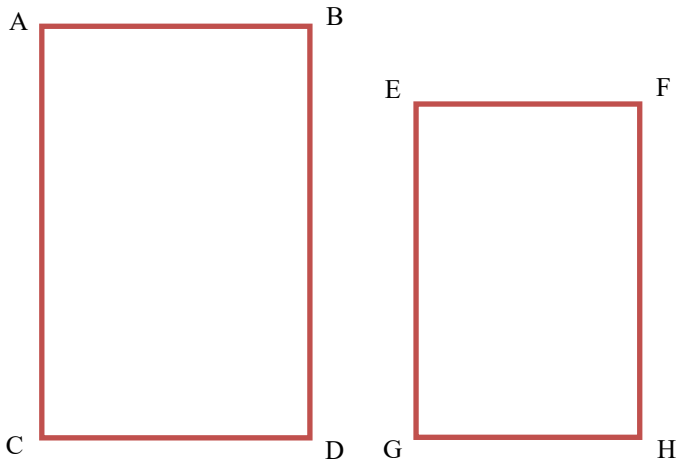

Figure 4. Rectangular geometry

The elements of similarity based on figure 4 are:

[1] Corresponding angles are equal.

$$\angle A = \angle E$$
$$\angle B = \angle F$$

$$\angle C = \angle G$$
$$\angle D = \angle H$$

[2] Corresponding sides have the same ratio..

$$\frac{AB}{EF} = \frac{AC}{EG} = \frac{CD}{GH} = \frac{BD}{FH}$$

3.3. Concept of building space

3.3.1. Build a ball room

The spherical geometry is one of the geometry that is often found in various applications of mathematics and physics, for example in measuring the volume of spherical objects or in analyzing symmetry properties. Several studies have shown that the sphere is a perfect example of a geometry with very high symmetry, both rotational symmetry and reflection symmetry. For example, in the Journal of Mathematics Education in 2022, it is discussed that teaching about spheres in class often focuses on calculating volume and surface area, the formulas of which are very relevant in real-life contexts, such as in calculating the capacity of spherical objects [22].

The next process in making Cang Kuning cake is to make a ball filling made of brown sugar and grated coconut. In addition, there is also dough on the inner layer which is used to wrap the grated coconut and brown sugar filling, forming a ball. Geometrically, this produces a spherical geometry, which can be seen in Figure 5.

Figure 5. Filling and layers in cangkuning cake
Source: https://youtu.be/ZEugHFsw4Z0?si=8TvixAF4u90QukfN

Based on the observation results, the concept of spatial shapes was found in the process of making Cang Kuning cake. From interviews and observations, it is known that the filling of Cang Kuning cake contains the concept of spatial shapes, namely spherical spatial shapes. Geometrically, the filling of Cang Kuning cake can be seen in Figure 6.

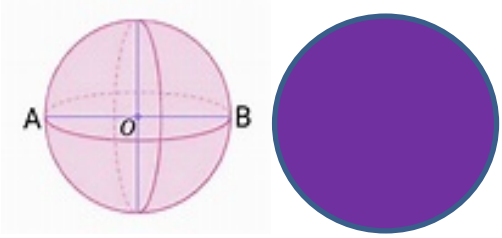

Figure 6. Geometry of yellow cang cake filling

A sphere is a three-dimensional geometric figure that has a curved surface formed by a curved plane and has a center point in the middle. The sphere is included in the curved-sided geometric figure because its surface is curved, not flat.

based on Figure 5, the elements of a sphere are:

1. Has one center point;
2. Has one side;
3. Has a radius, which is a straight line that starts at the center point and ends at the surface of the sphere (r).

From observations, because the filling of Cang Kuning cake is in the shape of a sphere, the volume of the sphere can be calculated.

$$V_{bola} = \frac{4}{3}\pi r^3$$

Where,
r = ball fingers
π = phi (3,14 or 22/7).

3.3.2. Limas Segiempat

A rectangular pyramid is a geometric figure that has a rectangular base (usually a square) and vertical sides in the form of triangles that meet at one point. This geometric figure is often used in the context of geometry learning to introduce more complex concepts of volume and surface area. According to research published in the International Journal of Geometry Education in 2023, a rectangular pyramid is a good example for teaching basic concepts of the volume of a geometric figure. The rectangular pyramid also has important relevance in introducing students to the relationship between the volume and height of a geometric figure. Teaching students how to visualize and calculate the volume of a pyramid through a contextual approach, such as using physical models or real applications, can improve students' understanding of this concept [23].

The next step, the leaf is folded into a certain pattern, then a white layer is inserted into the folds of the leaf. After that, the Cang Kuning cake filling is placed on top of the white layer, then another white layer is added enough to cover the cake filling, as seen in Figure 7. The process is then continued by closing the leaf using certain folds that follow a special pattern, thus forming a Cang Kuning cake, as seen in Figure 8.

Figure 7. Inserting the filling of the
Source: https://youtu.be/ZEugHFsw4Z0?si=8TvixAF4u90QukfN

Figure 8. Cangkuning cake
Source: https://youtu.be/ZEugHFsw4Z0?si=8TvixAF4u90QukfN

Geometrically, Cangkuning cake is shaped like a square pyramid with a ball inside it, as illustrated in Figure 9.

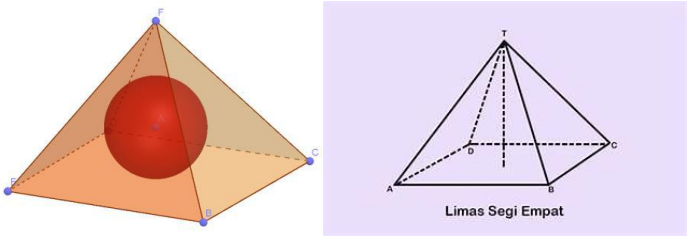

Figure 9. geometric illustration on yellow cang cake

The elements of a square pyramid consist of:

1. Has 5 sides, namely 1 base side and 4 vertical sides.
2. The base side is rectangular.
3. The four vertical sides are triangular.
4. Has five corner points.
5. Has eight edges.

6. Volume

Because Cangkuning cake is pyramid-shaped, the volume of this shape can be written asdituliskan

$$V = \frac{1}{3} \times luas\ alas \times tinggi$$
$$= \frac{1}{3} \times luas\ alas \times tinggi$$
$$= \frac{1}{3} \times b^2 \times h$$

This study identified various mathematical concepts contained in making Cang Kuning cake, such as comparison, similarity, spherical geometry, and square pyramid. The concept of comparison is found in the measurement of cake ingredients, for example a 2:1 ratio between black glutinous rice and white glutinous rice to create cake layers. The concept of similarity is observed in the rectangular cake wrapping leaves, with different sizes but still similar. The spherical geometry is reflected in the filling of brown sugar and grated coconut, while the overall shape of the cake resembles a square pyramid after being wrapped in banana leaves with a certain technique. These geometric elements provide new insights into the application of mathematical concepts in local culture [17], [24]. The limitations of this study include a small sample, only covering one type of food, and the dominance of qualitative data.

Exploration of ethnomathematics in traditional food makes a significant contribution to more contextual mathematics learning. Research by Amaliah et al. [25] shows that the integration of local culture into mathematics learning increases the relevance of the material and students' motivation. In addition, research by Chen et al. [26] on culture-based mathematics education in Asia revealed the importance of using cultural objects to improve students' understanding of geometry and mathematical patterns. Furthermore, research on traditional food as a source of mathematics learning continues to grow. For example, research by Zhang and Wang [27] examined ethnomathematics in traditional Chinese food and found that the concepts of symmetry and geometric transformations often appear in the process of making it. In the Indonesian context, research by Sakinah et al. [28] discussed the application of ethnomathematics to Tumbu Bugis, emphasizing the importance of a culture-based approach to increase the relevance of mathematics learning to students' daily lives.

The ethnomathematics approach also contributes to the development of technology-based learning media. A study by Veruggio et al. [29] shows how digital media can be used to document and teach mathematical concepts from local cultures. In addition, a study by Zhao et al. [30] proposed a 3D visualization method to represent geometric elements in traditional foods, increasing students' interest in learning mathematics. Through an ethnomathematics approach, traditional foods such as Cang Kuning are not only a medium for learning mathematics but also a tool for preserving local culture. By understanding the mathematical concepts contained in culinary traditions, students not only learn abstractly but also understand the real applications of mathematics in their lives [31].

4. CONCLUSION

In this study, the expectations stated in the "Introduction" chapter have been well realized in the "Results and Discussion" chapter. This study successfully revealed that the traditional Cang Kuning food not only functions as a dish, but is also rich in mathematical concepts that can be explored further. Through an in-depth analysis of the process of making this cake, various mathematical elements were found that were very relevant to the concepts taught in mathematics, such as geometry, comparison, similarity, and the application of spherical and pyramidal solids. These findings show that mathematics is not only present in the form of abstract formulas or theories, but can also be found in everyday life, especially in local culture. This makes mathematics closer and easier to understand for students, especially those from similar cultural backgrounds. This study proves that through the association of local culture, such as Cang Kuning, students can see directly the relevance between mathematical concepts and their real lives, which were previously considered distant and unrelated.

The prospect of developing the results of this study is very promising, especially in the integration of ethnomathematics concepts into the mathematics education curriculum. This study provides an overview that mathematics learning based on local culture can improve students' understanding of mathematical concepts, because they can see their practical application in everyday life. Linking learning materials with local culture not only makes it easier to understand, but also increases students' interest in learning mathematics. In addition, the development of technology-based learning media that integrates ethnomathematics concepts is a very strategic step. With the existence of interactive digital media that combines mathematics learning with local culture, students can more easily access information and learn in a more interesting and relevant way. Technology can play an important role in creating a more dynamic and enjoyable learning experience, allowing students to learn independently and exploratively

In addition, further research is also needed to test the effectiveness of this approach through quantitative methods. Quantitative research can measure the impact of using an ethnomathematics approach on students' understanding and motivation to learn. With more measurable data, educators can be more confident in implementing this approach in the classroom. Overall, by integrating cultural elements into mathematics learning, it is hoped that students will not only be able to understand mathematical concepts theoretically, but also develop a sense of pride in their local cultural heritage. This approach can create a deeper, more meaningful, and more relevant learning experience to the context of students' lives, as well as foster their awareness of the importance of preserving local culture through education. Therefore, this study makes a major contribution to creating a more contextual and interesting mathematics learning model for students. The limitations of this study include a small sample, only covering one type of food, and the dominance of qualitative data. Recommendations for future research include quantitative effectiveness testing in the classroom and the development of digital learning media based on ethnomathematics.

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