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Ethnomathematical Exploration of Tegal Traditional Food as Source of Contextual Problems in Problem-Based Learning Model

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Abstract

This study aims to explore the ethnomathematical values found in traditional foods of Tegal and to identify their potential as alternative sources of contextual problems in mathematics learning based on Problem Based Learning (PBL). The research employed a qualitative approach with an ethnographic method through literature review and visual observation using secondary documentation. Data were collected from various written sources and relevant images, then analyzed to reveal the geometric shapes and mathematical concepts embedded within them. The exploration results indicate that six types of traditional Tegal foods, namely *tahu aci*, *bogis poci*, *olos*, *alu-alu*, *kamir*, and *apem*, possess geometric forms that can be linked to concepts of solid geometry, plane geometry, and algebra. These findings provide a foundation for designing contextual problems aligned with the principles of PBL, where students are presented with real-world problems, work collaboratively, and construct meaningful understanding. This study does not measure learning effectiveness but produces a thick description that can serve as a reference for teachers and curriculum developers in integrating local wisdom into mathematics learning.

1. Introduction

Mathematics is a discipline that plays a crucial role in everyday life and significantly contributes to the development of logical, systematic, and analytical thinking skills. However, mathematics learning in schools is often perceived as difficult, abstract, and disconnected from students' real-life contexts (Yanti, 2024). The lack of connection between the mathematical concepts taught and students' real experiences results in low learning motivation and conceptual understanding. This condition highlights the need for learning strategies that can bridge mathematical concepts with the realities surrounding students. One such strategy is integrating local cultural contexts into mathematics instruction, making learning materials more relatable, meaningful, and engaging for students (D'Ambrosio, 1985).

Ethnomathematics is an approach that examines how mathematical concepts are practiced in various cultures (Fajria Septiani, 2024). This approach utilizes cultural elements familiar to students to introduce and develop mathematical concepts in a contextual manner. In the Indonesian educational context, which is rich in cultural heritage, ethnomathematics opens opportunities to create a more humanistic and socially relevant learning environment. One form of local wisdom with strong potential as a learning resource is traditional food. The shapes, patterns, and production processes of traditional foods contain mathematical elements that can be explored, such as geometry, measurement, and proportion.

The Problem Based Learning (PBL) model is well-suited to harness the potential of local culture as it emphasizes learning through solving real and contextual problems. In PBL, students are encouraged to gather information, identify problems, analyze, and formulate solutions through group collaboration

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(Fristadi & Bharata, 2015). The PBL syntax, adapted from Polya, consists of five stages: (1) problem orientation, (2) organizing students, (3) guiding investigations, (4) developing and presenting results, and (5) analyzing and evaluating the problem-solving process. By incorporating cultural contexts such as traditional foods, teachers can present contextual problems that foster student engagement while cultivating an appreciation for local culture.

Tegal City offers a variety of traditional foods such as *tahu aci*, *olos*, *alu-alu*, *bogis poci*, *kamir*, and *apem*. Each has distinctive geometric forms, such as triangular prisms, cylinders, square pyramids, spheres, circles, or cones. These unique forms provide opportunities to serve as contextual problem sources that link mathematical concepts to students' daily lives (Abi, 2017). Through an exploratory approach, the shapes and mathematical concepts embedded in these foods can be identified and developed into example problems or learning scenarios aligned with the PBL model.

In addition to enriching instructional content, the integration of ethnomathematics into PBL supports the formation of the Pancasila Student Profile, particularly in the dimensions of global diversity and cooperation (Kemendikbudristek, 2022). Local culture-based learning encourages students to recognize and preserve regional heritage while honing critical thinking, collaboration, and problem-solving skills. Research by Maharani and Muhtar (2022) indicates that local wisdom-based learning can foster cultural awareness and develop student character.

Teachers play a vital role in selecting and framing local cultural contexts so they align with learning objectives. Traditional foods can be used as problem stimuli that challenge students to observe, classify shapes, measure dimensions, or model real-life situations into mathematical problems (Sausanti et al., 2024). One advantage of using traditional foods in learning is their ability to bridge abstract concepts into concrete forms. For example, the spherical shape of *olos* or the conical form of apem can be used to introduce solid geometry in a tangible and engaging way (Sausanti et al., 2024).

Integrating cultural values into mathematics learning also creates opportunities for cross-disciplinary instruction. Students not only develop numeracy skills but also learn about the history, cultural meaning, and social values of the objects studied. This approach aligns with the *Merdeka Belajar* paradigm, which promotes meaningful and relevant learning experiences. Ilmiyah et al. (2021) highlight that ethnomathematics-based learning can enrich students' educational experiences and foster a sense of pride in their cultural heritage.

Based on this background, this study aims to explore and identify the ethnomathematical values embedded in Tegal's traditional foods and to develop them as alternative contextual problems for mathematics learning using the Problem Based Learning model. The focus of the study is on idea generation, shape description, and potential applications, rather than on testing the effectiveness or impact on student learning outcomes. The results of this study are expected to serve as a reference for teachers in developing local culture-based learning materials that are both contextual and engaging.

2. Methods

This study employed a qualitative approach with an ethnographic method to explore the ethnomathematical values embedded in traditional foods of Tegal and to identify their potential as alternative sources of contextual problems in mathematics learning based on Problem Based Learning (PBL). The ethnographic method was chosen because it enables the researcher to describe and interpret cultural phenomena through in-depth observation of artifacts, activities, and the meanings associated with community life (Creswell, 2018). In this context, traditional foods are viewed as cultural artifacts containing mathematical concepts that can be integrated into contextual learning.

Data were collected through a literature review and visual observation based on secondary documentation. The literature review was used to establish the theoretical framework on ethnomathematics, contextual learning, the PBL model, and studies related to Tegal's traditional foods. Literature sources were obtained from national and international journals, books, conference proceedings, and relevant official documents (Fatimah et al., 2025). Searches were conducted via Google Scholar, Garuda, DOAJ, and ResearchGate using the keywords "ethnomathematics," "Tegal traditional food," "contextual problem," and "Problem Based Learning."

Visual observations were carried out on six types of traditional Tegal foods, namely *tahu aci*, *olos*, *alu-alu*, *bogis poci*, *kamir*, and *apem*. These observations were based on photographic documentation and descriptions from open-source online materials, complemented by the researcher's direct empirical experience in observing the actual shapes of these foods. This technique was used to identify geometric shapes, proportions, and physical characteristics relevant to mathematical concepts.

The research process began with the selection and determination of traditional foods considered to represent Tegal's cultural heritage and possessing distinctive geometric shapes. Each food was then visually examined to describe its form in detail, including proportions, symmetry, and possible connections to mathematical concepts such as solid geometry, plane geometry, or systems of linear equations in two variables. These descriptions were subsequently analyzed to identify the ethnomathematical values they contain, both in terms of physical form and the cultural meanings associated with them. Based on this analysis, the researcher designed examples and ideas for contextual problems that could be used in PBL, positioning traditional foods not merely as cultural artifacts but also as sources of inspiration for developing teaching materials.

Data validity was ensured through source triangulation by comparing findings from the literature with the results of visual observations, and by verifying shape classifications against geometric references as well as alignment with the *Merdeka* Curriculum and numeracy assessment indicators (Miles et al., 2014). Through this documentation-based ethnographic approach, the study seeks to provide a thick description of the forms, meanings, and potential uses of Tegal's traditional foods in mathematics learning, thereby serving as a reference for teachers in developing contextual, meaningful, and local wisdom-based instruction.

3. Results & Discussions

The exploration of ethnomathematical values within the local context serves as a crucial foundation for developing meaningful mathematics learning. One form of implementation is the introduction of traditional culinary culture as an entry point for understanding mathematical concepts in a contextual manner. In this study, traditional foods from Tegal were selected due to their close connection to students' daily lives, their distinctive geometric shapes, and their potential to be represented in the teaching of geometry as well as other mathematical topics.

The findings reveal that each type of traditional food analyzed possesses a geometric form that can be associated with specific mathematical concepts. *Tahu aci* resembles a triangular prism, *bogis poci* takes the form of a square pyramid, *olos* resembles a sphere, alu-alu takes the form of a cylinder, *kamir* is shaped like a flat circle, and *apem* resembles a cone. These associations create opportunities for teachers to present mathematics content in the form of contextual problems that are closely related to students' everyday experiences. This approach enables students to connect the concepts they learn in class with objects they encounter in their socio-cultural environment (D'Ambrosio, 1985).

3.1. Tahu Aci

Figure 1. *Tahu Aci*

Tahu aci is one of Tegal's culinary icons. This food is made from pieces of tofu filled with seasoned starch (*aci*) dough, then fried until crispy. Besides being a popular snack, *tahu aci* is also a symbol of the cultural identity inherent in Tegal society. If you look at the picture, the shape of the *tahu aci* resembles a triangular prism. Thus, *tahu aci* can be used as an interesting learning media to introduce the concept of space to students, especially the shape of a triangular prism. This shows that local cultural elements can be part of the contextual approach in education, where typical food such as *tahu aci* is not only a symbol of the identity of the Tegal community, but also a bridge between culture and learning.

3.2. Bogis Poci

Figure 2. *Bogis Poci*

Bogis poci is a traditional snack from Tegal wrapped in banana leaves and pointed at one end. Inside is a glutinous rice flour-based dough with a sweet coconut unti filling. Visually, the shape of *bogis poci* resembles a quadrilateral pyramid, which is a space that has a rectangular base and triangular upright sides that meet at one vertex. The picture above shows the outline of a quadrilateral pyramid clearly, making *bogis poci* an interesting example in geometry learning.

3.3. Olos

Figure 3. *Olos*

Olos is a typical Tegal food in the shape of a small round filled with chillies or vegetables, then fried until crisp. The round shape of *olos* resembles a sphere or spherical space. Because of its distinctive shape, *olos* is very potential to be used as a context for learning geometry, especially on the material about the volume and surface area of the sphere.

3.4. Alu-alu

Figure 4. *Alu-alu*

Alu-alu is a typical Tegal snack that has a small elongated shape resembling a cylinder. It is made from a mixture of flour shaped into an oval and fried until browned. Crispy on the outside and soft on the inside, it is often used as a snack or sold by street vendors. Its tube-like shape makes it relevant to the concept of tube geometry in mathematics learning. Because of its uniform and distinctive appearance, *alu-alu* can also be used as a contextual object in culture-based maths problems.

3.5. Kamir

Figure 5. *Kamir*

Kamir is a flat, round-shaped speciality of Tegal, often likened to traditional bread. *Kamir* is made from a dough of wheat flour, yeast and eggs, then baked. The texture is soft and slightly dense, with a golden brown surface. Its round and flat disc-like shape makes it interesting to associate with the flat shape of a circle. *Kamir* is usually served as a snack or breakfast food.

3.6. Apem

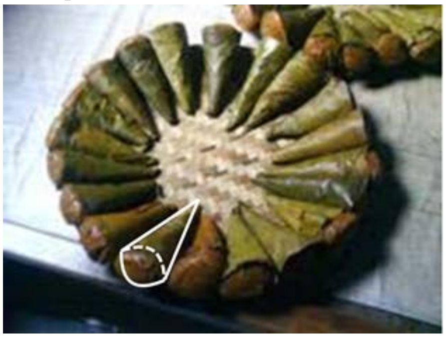


Figure 6. *Apem*

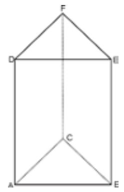
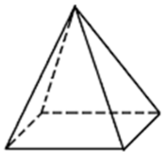
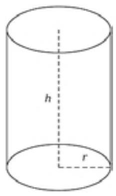
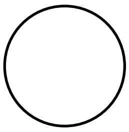
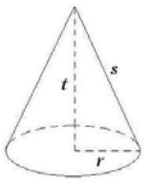
Apem is a traditional Javanese snack that is rarely recognised by the younger generation. In fact, this food is one of the valuable culinary cultural heritages. In Tegal, *apem* has a different shape compared to other regions in Java. Its flavour is distinctive and strong, making it different from other *apem* variants. Tegal *apem* is made from rice flour, brown sugar and cassava tape wrapped in a cone-shaped banana leaf. The combination of these ingredients produces a unique sweet and savoury flavour, perfect for any occasion. Seen in the picture, the shape of *apem* resembles the shape of a cone. A cone has one apex and one circular base, with a curved side that holds it together. Through its distinctive shape, Tegal *apem* can be an interesting learning media to introduce cone shape to students in a contextual and fun way.

3.6. Geometric Shape Analysis of Tegal Food

The results of this study show that Tegal's traditional food not only has cultural value, but can also be used as a medium for contextualised mathematics learning. Through the ethnomathematics approach, students are invited to understand mathematical concepts through objects that are close to their lives, thus increasing learning engagement (D'Ambrosio, 1985). In this case, the geometric shapes of food such as *tahu aci*, *alu-alu*, *olos*, and *apem* become a means to introduce the concept of building space concretely. This kind of approach not only improves students' conceptual understanding, but also strengthens local cultural values that are starting to be marginalised (Bimantara, 2024). This implementation is in line with the first step of the Problem Based Learning (PBL) model, namely orientation to contextual problems.

In addition to geometry, the application of two-variable linear equation systems in the context of buying and selling traditional food can also strengthen the connection between mathematics and real life. When students construct and solve SPLDV based on local economic activities, they not only practice algebraic skills, but also build critical thinking and problem-solving skills (Fristadi & Bharata, 2015). For example, if someone buys three *tahu aci* and two *alu-alu* for a total price of IDR19,000, and another buyer buys two *tahu aci* and four alu-alu for IDR22,000, then this situation can be modelled into a system of equations.

Tabel 1. Geometric Shape Analysis of Tegal's Typical Food

No	Characteristic Food	Geometric Shape	Related Math Concepts
1	*Tahu Aci*	 Triangular prism	Volume, surface area of triangular prism
2	*Bogis poci*	 Quadrilateral pyramid	Volume, surface area of a quadrilateral pyramid
3	*Olos*	 Ball	Volume of ball, surface area of ball
4	*Alu-alu*	 Tube	Volume, tube (outer)area
5	*Kamir*	 Circle	Area of a circle, circumference of a circle
6	*Apem*	 Cone	Volume, height and radius of a cone

The solution steps of the following example problem:
Unknown:
A customer buys 3 *tahu aci* and 2 *alu-alu* for Rp19,000.
Another buyer bought 2 *tahu aci* and 4 *alu-alu* for Rp22,000.
Ask:
What is the price of one *tahu aci* and one *alu-alu*?

Answer:
Step 1: Define the variables
Suppose:
x= the price of one tofu (*tahu aci*)
y= the price of one *alu-alu*
Step 2: Set up a system of equations
From the known information we can obtain:
$3x + 2y = 19.000$ ... (equation 1)
$2x + 4y = 22.000$ ... (equation 2)
Step 3: Solving the system of equations
Multiply equation (1) by 2 so that the coefficient of the variable y is equal to equation 2
$3x + 2y = 19.000 | \times 2 | \rightarrow 6x + 4y = 38.000$
Eliminate equations (1) and (2)
$6x + 4y = 38.000$
$\underline{2x + 4y = 22.000}$ _
$4x = 16.000$
$x = \frac{16.000}{4}$
$x = 4.000$
Substitute $x = 4.000$ into equation (1) or equation (2)
$3x + 2y = 19.000$
$\Leftrightarrow 3(4.000) + 2y = 19.000$
$\Leftrightarrow 12.000 + 2y = 19.000$
$\Leftrightarrow \quad 2y = 19.000 - 12.000$
$\Leftrightarrow \quad 2y = 7.000$
$\Leftrightarrow \quad y = 3.500$
Step 4: Summarise
So, it can be concluded that the price of 1 *tahu aci* is Rp4,000 and the price of one *alu-alu* is Rp3,500.

Modelling like this shows that SPLDV material is not abstract, but can be related to the economic activities of the local community. This process is in line with the problem identification and information seeking stages in Problem Based Learning. This context encourages students to develop numeracy skills based on cultural literacy, as demanded by the Merdeka Curriculum (Kemendikbudristek, 2022). Thus, the ethnomathematics approach integrated with Problem Based Learning enriches the material content and learning strategies.

From an ethnographic perspective, these foods are not merely culinary artifacts but also part of the cultural identity of the people of Tegal. *Tahu aci*, for example, is an icon closely associated with the city's image, while *apem* holds symbolic dimensions in certain traditions. Highlighting these aspects in teaching aligns with the view that cultural artifacts can serve as educational media that integrate local knowledge into the learning process. In this way, teachers are not only teaching mathematics but also instilling cultural values and fostering students' pride in their place of origin.

The potential use of traditional foods as a source of contextual problems is also consistent with the principles of Problem Based Learning (PBL), which positions real-world problems as the primary trigger for learning. At the problem orientation stage, teachers can use images or even bring physical examples of the foods into the classroom to spark discussion. Students may be asked to identify their geometric shapes, measure relevant dimensions, or model situations related to prices and quantities, as recommended in problem-based learning approaches that emphasize connections with students' concrete experiences.

This process can then proceed to the stage of organizing students for learning, in which the teacher divides them into small groups to discuss the given problems. The problems constructed not only test computational skills but also encourage students to understand the relationship between mathematics and real life. For instance, groups may be tasked with calculating the volume of *olos*, the surface area of *apem*, or estimating the quantity of ingredients needed to produce a certain number of *tahu aci*, which in practice strengthens the link between mathematical concepts and their applications.

The investigation stage provides students with the opportunity to explore information in greater depth, whether through direct measurement if feasible or by researching relevant data. In this context, the teacher acts as a facilitator, guiding the process of finding solutions. By using the context of traditional foods, students can more easily build connections between the data they collect and the mathematical concepts being studied, as they are working with familiar objects that hold cultural relevance.

The development and presentation stage allows students to express their understanding in oral or visual formats. For example, groups may present diagrams, calculations, or simple 3D models of the food shapes they have analyzed. This activity aligns with findings that local wisdom-based learning can improve students' communication skills and teamwork. Presenting their results also encourages students to articulate their thinking processes, which is essential for developing metacognitive skills.

The final stage, analysis and evaluation of the process, is used to reflect on the strategies applied. Teachers can invite students to compare the approaches used by different groups, identify strengths and weaknesses, and discuss how cultural values can be integrated into mathematics learning. Such reflection is an important part of contextual learning, as it helps students realize the relationship between their learning experiences, the concepts studied, and the cultural meanings embedded in the context.

This study also demonstrates that integrating ethnomathematics and PBL can broaden the scope of learning. In addition to teaching abstract mathematical concepts, teachers can incorporate information about the history, symbolic meaning, and social role of these foods in the community. As a result, students gain interdisciplinary learning that combines numeracy skills, cultural literacy, and social awareness.

The findings of this exploration are not intended to measure the effectiveness of learning or quantitatively assess students' skill improvement, as is often the goal of experimental studies. Rather, they aim to map the significant potential of Tegal's traditional foods as a source of ideas for contextual problems in PBL. The descriptions of geometric shapes, related mathematical concepts, and usage scenarios can serve as an initial reference for teachers in developing local wisdom-based learning materials aligned with the *Merdeka* Curriculum.

In conclusion, this discussion affirms that traditional foods are not only cultural heritage but can also serve as a bridge connecting mathematics with students' real lives. Exploring ethnomathematics in this context opens opportunities for more contextual, interactive, and relevant learning while fostering cultural awareness among students.

4. Conclusion

This study explored the ethnomathematical values embedded in six traditional foods from Tegal, namely *tahu aci*, *bogis poci*, *olos*, *alu-alu*, *kamir*, and *apem*, highlighting their potential as contextual problems in mathematics learning based on Problem Based Learning (PBL). The analysis revealed that each food embodies distinct geometric shapes such as triangular prisms, square pyramids, spheres, cylinders, flat circles, and cones, which can be linked directly to mathematical concepts. Furthermore, opportunities were found to integrate algebraic concepts, particularly systems of linear equations in two variables, by modeling real life situations like the buying and selling of traditional foods in local markets. This demonstrates that local cultural artifacts can bridge the gap between mathematical concepts and students' real world experiences, enriching the classroom environment. Through an ethnographic approach, the study not only described the physical forms of these foods but also captured the cultural values embedded in them, positioning traditional foods as sources of inspiration for context based mathematics learning. Although this research does not measure the quantitative effectiveness of learning, it provides recommendations for teachers to develop locally inspired teaching materials. The findings offer insights into designing contextual problems aligned with PBL principles, emphasizing real world problems, collaboration, and meaningful understanding. In conclusion, the integration of ethnomathematics in Tegal's traditional foods holds significant potential to enhance mathematics learning, fostering both conceptual understanding and cultural appreciation among students. Teachers and curriculum developers are encouraged to consider these findings when designing contextual, interactive, and locally rooted learning experiences.

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