

Intuitive Ethnomathematics: A Case Study of Lopi Sandeq's Construction Non Formal Math Calculations

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Abstract

Ethnomathematics plays a crucial role in exploring Indonesia's rich cultural diversity, particularly concerning the Lopi Sandeq, a traditional boat of the Mandar Tribe in West Sulawesi. This research investigates the intuitive ethnomathematics employed in the construction of the Lopi Sandeq, a process that traditionally eschews formal mathematical calculations. The study aims to delve into how intuition, honed through generations of experience and acute visual perception, serves as the primary determinant for achieving the boat's renowned balance and precision. Utilizing a qualitative approach with an interpretive phenomenological design, the research gathered data through in-depth interviews, participatory observation, and documentation from experienced Lopi Sandeq boat builders (passandeq) in West Sulawesi. The findings reveal that while basic measurements may be used as initial references, critical decisions regarding the boat's balance and symmetry are predominantly based on subjective, adaptive assessments, deeply internalized feelings, and visions developed over decades. This intuitive approach, which incorporates concepts like symmetry, proportion, and basic measurements, demonstrates that technical precision can be achieved through non-formal knowledge pathways. The study highlights that the construction of Lopi Sandeq reflects a unique integration of cultural values, such as the symbolic use of odd numbers and shapes resembling Arabic letters, and practical, empirically derived knowledge. This research enriches ethnomathematical perspectives by demonstrating diverse ways humans apply spatial and equilibrium principles within cultural contexts, underscoring the validity and effectiveness of non-formal knowledge. The intuitive wisdom

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embedded in Lopi Sandeq construction serves as tangible evidence of a rich cultural heritage, offering valuable lessons in adaptation, innovation, and human-environment harmony. It also provides a robust case study for teaching mathematical concepts in a meaningful and culturally relevant way

Keywords: Ethnomathematics, Lopi Sandeq, Intuition, Traditional Boat, Local Wisdom.

INTRODUCTION

As a country with rich cultural diversity, Indonesia holds excellent potential for ethnomathematical exploration. One interesting example is the Lopi Sandeq, a traditional boat originating from the Mandar Tribe in West Sulawesi, offering a unique opportunity for ethnomathematical research that has not been widely explored (Yusuf, M., Sudirman, A., & Maulidah, 2024). One of the cultural traditions rich in mathematical values is the tradition of making and using Lopi Sandeq (Sunubi, A. H. 2017). This traditional Mandar boat is famous for its speed and toughness. Lopi Sandeq not only has high cultural and historical value but also contains a variety of mathematical concepts that can be explored. Creating and using Lopi Sandeq involves various mathematical elements, such as measurement, symmetry, proportion, and geometric design.

Lopi Sandeq symbolizes the courage and skill of the Mandar people and has an essential function in their daily lives, especially in shipping activities (Fitrah, A. N., et al, 2024 ; Sonni, A. F., et al 2021). The distinctive design of Lopi Sandeq, which was built by utilizing local knowledge of materials and techniques, shows how the Mandar people applied mathematical principles in practice. For example, in determining the boat's dimensions, the Mandar people use careful measurements to ensure the boat is balanced and can sail properly. In addition, Lopi Sandeq is not only a symbol of the cultural identity of the Mandar people but also full of the application of mathematical concepts in various aspects, from design and construction to navigation and competition or in other words reflecting the application of various mathematical concepts such as geometry, measurement, and proportion (Asfarilla, V., & Prihatmaji, Y. P. 2019). Lopi Sandeq artisans must make precise measurements to ensure the balance and speed of the boat, as well as use navigation knowledge based on natural phenomena such as wind direction and ocean currents.

The process of making and using Lopi Sandeq involves the application of complex and diverse mathematical principles. For example, in determining the size and proportions of boats,



Lopi Sandeq artisans use traditional measurement techniques that require a deep understanding of geometry and arithmetic. Using boats in marine navigation also involves mathematical knowledge of direction, distance, speed, and time, all of which relate to coordinates and trigonometry (Stanivuk, T., et al, 2017; Srientini, A., & Abadi, A. 2024). Meanwhile, the process of making it, Lopi Sandeq artisans must make precise dimensional measurements to ensure the balance and speed of the boat, as well as use navigation knowledge based on natural phenomena such as wind direction, and sea currents. Thus, this tradition provides a rich, real context for teaching mathematical concepts to students in a more meaningful and relevant way.

In the maritime culture of the archipelago, Lopi Sandeq stands out as a valuable heritage of the Mandar people in West Sulawesi (Mattiuro, S., et al, 2023). These sleek outrigger boats are not just a means of transportation or fishing; They are a tangible manifestation of local wisdom passed down from generation to generation. Sandeq's speed and stability in the open seas are often stunning, raising questions about how such a precise design could have been created. Modern boat construction generally involves complex mathematical and physical calculations to ensure optimal balance and performance. However, the makers of Lopi Sandeq have traditionally not relied on formal formulas or sophisticated software. Instead, they adhere to intuition, experience, and keen eyesight in determining every construction detail, from the hull's shape to the outrigger's position.

This phenomenon of intuitive wisdom is the primary focus of this paper. Instead of formal mathematics, *the passengers* (Sandeq makers) use feelings and visions honed over decades, even across generations. Although basic measurements such as initial length and width may be used, crucial decisions regarding balance and symmetry are often born from highly internalized subjective judgments. This approach suggests that other forms of knowledge are just as valid, even very effective, in achieving technically desirable results.

Through the perspective of the boatbuilder community, this article aims to dig deeper into how intuition works in Sandeq's construction practice, exploring the non-verbal dimensions of this knowledge and understanding how collective experience and profound observation shape the perspectives of Sandeq builders. Thus, this research is expected to provide new insights into local ethnomathematics and appreciate the traditional values contained in every inch of Lopi Sandeq.

RESEARCH METHODS

This study uses a qualitative approach with an interpretive phenomenological design (Frechette, J., et al, 2020; Larkin, M., et al, 2019). The phenomenological approach was chosen to



deeply understand the subjective experiences and perspectives of Sandeq boat builders regarding the use of intuition in the construction process. Interpretive design allows researchers to interpret the meaning behind the experience, uncovering how intuition is manifested and understood in the context of their culture and practice (Schwartz-Shea, P., & Yanow, D. 2013; Thorne, S. 2016).

Research participants will be selected by purposive sampling (Campbell, S., 2020; Rai, N., & Thapa, B. 2015). The main criteria for selecting participants are those who are experienced and recognized Sandeq (*passandeq*) boatbuilders in their communities with a long track record in traditional boat construction. Participants will be sought at Sandeq manufacturing centres in West Sulawesi, such as Polewali Mandar Regency. The number of participants will be determined based on data saturation, i.e. when no significant new information emerges from additional interviews or observations. Data will be collected through three main techniques:

1. In-depth Interview: The interview will be conducted in a semi-structured manner with the *passandeq*. Questions will be designed to dig into their experiences, how they learn and apply intuition in each stage of Sandeq's construction, how they feel the balance of the boat, and their views on the role of formal mathematics vs. "feelings" in their work. The interview will be audio-recorded and transcribed for analysis.
2. Participatory Observation: The researcher will conduct direct observation at the Sandeq boat manufacturing site. This observation aims to observe first-hand the work process of *passandeq*, their interaction with materials tools, and how they intuitively make crucial decisions regarding shape, size, and balance. The researcher will record essential details in the field notes.
3. Documentation: Supporting data will be collected from various documents, such as photos, videos, or community records related to the history of Sandeq creation or *passandeq figures*. This documentation will help enrich the researcher's context and understanding.

The collected data will be analyzed using the thematic analysis method from Braun and Clarke (Clarke, V., & Braun, V, 2017; Byrne, D. 2022). The analysis steps include:

1. Data Familiarization: Researchers will repeatedly read interview transcripts, observation notes, and documents to gain a thorough understanding of the data.
2. Initial Coding: Relevant pieces of data will be identified and given a descriptive initial code.
3. Reviewing Themes: Themes will be examined for relevance, internal coherence, and differences between themes.



4. Defining and Naming Themes: Each theme will be clearly defined and given a representative name.
5. Producing the Report: Findings will be presented narratively, supported by direct quotes from participants and descriptions of observations, to explain the intuitive wisdom in constructing Lopi Sandeq.

RESULTS AND DISCUSSION

This research reveals the ethnomathematics of intuition in Lopi Sandeq as a source of mathematics learning by involving three experienced key informants in making the traditional boat. The three subjects were chosen based on their expertise and their having been pursuing the making of Lopi Sandeq for many years despite having different scientific backgrounds, professions, and ages. The First Subject (SB1) is 47 years old and works as a fisherman. His expertise in making Lopi Sandeq began in 1999, and he has won several victories in the Sandeq Race Competition. The Second Subject (SB2) is 54 years old with a primary profession as an electronics technician. Although he does not have a maritime background, his Lopi Sandeq won 1st place at the provincial level in 2024. His work also enriched his experience as a housekeeper, and he has honed his boat-building skills since the 1990s. The Third Subject (SB3) is 59 years old and represents hereditary knowledge, studying the making of Lopi Sandeq from the family since 1989. He worked as a boatman and a housekeeper, with skills inherited from his ancestors for decades.

The differences in the backgrounds of the three subjects such as age, profession, and way of obtaining knowledge make this research rich in perspective. Although the basic process of making Lopi Sandeq is the same, the variety of their life experiences and sources of knowledge influence their way of thinking and designing techniques for boats. The data presented in this study came from the analysis of raw interview transcripts, which were processed to describe the thoughts of the three subjects related to integrating ethnomathematics in Lopi Sandeq. Thus, the diversity of informants not only strengthens the validity of the data but also enriches findings related to local wisdom manifested in the construction of this traditional boat.

The following is a summary of the results of the SB1 interview, which has been compiled in the form of a table, where the table is compiled in three different parts, namely related to the Sandeq Lopi Making Process, Mathematical Concepts in the Making of Sandeq Lopi, and Cultural Values and Traditions carried out (Table 1, Table 2), then complemented by ethnomathematical analysis.



Table 1 Sandeq Lopi Making Process

Time Code	Question	Answer (SB1)	Ethnomathematical Analysis
0:07:37	What is the process of making sander lopi from start to finish?	1. Making stripes (hulls).2. Installation of tombo boards/walls.3.Making <i>kalandara</i> (boat lip support).4. Arrangement of boat bones (<i>tajo'</i>). 5. Making <i>paccong</i> (pointed tip). 6. Making <i>berating</i> (frame), <i>palette</i> (deck), sail pole, and sail.7. Balance and speed trials.	- Symmetry Concept: Right-left symmetry must be balanced.- Basic Measurement: Distribution of the midpoint of the boat (e.g., 14 m long → 7 m midpoint).- Dynamic Balance: Adjustment of the sail mast based on trials.
0:05:43	How do you choose wood materials for the sandeq lope?	- <i>Lingaru</i> wood (light and strong) for the body.- <i>Kanduruang</i> wood (light) and <i>bitti/bala</i> (strong) for bones.- The thickness is adjusted to the strength and speed needs.	- Material Classification: Selection of wood based on physical properties (weight, strength).- Optimization: Combination of lightweight and strong wood for buoyancy efficiency and speed.
0:13:47	How do you make the back of the boat balanced?	- Waste (gradual engraving) is carried out to measure thickness.- Thickness adjustment based on experience and trials.	- Visual Estimation: The use of senses and experience to determine thickness.- Iterative Trials: A process of trial and error to achieve balance.

Table 2 Mathematical Concepts in Making Sandeq Lopi

Time Code	Question	Answer (SB1)	Ethnomathematical Analysis
0:16:02	Does it use formal mathematical concepts?	<i>"Never, we see with feelings... There are no school lessons. For example, when determining the balance, we use</i>	- Intuition vs Formalism: The dominance of intuition and practical experience over formal mathematics.- Non-Standard Geometry:

		<i>feelings like when looking for a partner."</i>	Pointed shapes and front-back asymmetry are arranged based on functional needs, not standard formulas.
0:17:38	Is there a mathematical comparison between the boat's length and the sail mast's height?	<i>"It cannot be calculated mathematically. The screen height is adjusted for the trial. For example, a 13 m boat → a 16 m sail mast, but it can be cut or added after the trial."</i>	- Adaptive Proportions: No fixed formula exists; proportions are empirically adjusted.- Trial as a Solution: Using trials to determine technical parameters.
0:53:47	Why should the number of hungry (support) people be odd?	<i>"Because God loves odd counts. Example: an odd date is chosen for a good day to go to sea."</i>	- Numerical Symbolism: Odd numbers are believed to bring blessings.- Local Wisdom: The integration of traditional beliefs in technical practice.

Based on the exposure of the data in the table above, it can be concluded that ethnomathematical practices in making sandeq lopi display a unique integration between culture and science. Although artisans like SB1 do not use formal mathematics, concepts such as symmetry, proportion, and basic measurements remain implicitly visible in the manufacturing process, where dynamic equilibrium and iterative testing are the primary methods for adjusting technical parameters. More than just the technical aspects, the use of odd numbers and pointed shapes in the ship's design also holds a symbolic meaning closely related to the Mandar people's local beliefs and religious values. This process reflects local wisdom combined with hereditary empirical knowledge and shows how contextual mathematics—inseparable from cultural values—operates within a practical and spiritual framework. Its educational potential is also significant:



the creation of the sandeq lope can be used as a case study to teach adaptive geometry, material optimization, and the principle of balance, as well as instilling values such as precision, patience in the iterative process, and appreciation of tradition. Thus, Lopi sandeq is a cultural heritage and a bridge to understanding science holistically through an artistic lens, proving that learning mathematics can be more meaningful when associated with a vibrant and valuable local context.

The following is a summary of the results of the SB2 interview, which has been compiled in the form of a table, where the table is also compiled in three different parts, namely related to the Sandeq Lopi Making Process, Mathematical Concepts in the Making of Sandeq Lopi, and Cultural Values and Traditions carried out (Table 3, Table 4), and equipped with ethnomathematical analysis.

Table 3. Sandeq Lopi Making Process

Time Code	Question	Answer (SB2)	Ethnomathematical Analysis
00:32:40	How do you make a boat?	1. Buy large wood that has been processed semi-finished. 2. Carving wood to form <i>a baking</i> (back hull).3. Combining wooden boards with stubs.4. Adjust the shape by manual sculpting.5. Using tools such as meters and <i>elbows</i> for measurements.	- Practical Measurement: Use of meters and <i>elbows</i> for dimensional accuracy.- Dynamic Proportions: Adjust shapes based on experience rather than formal mathematical formulas.
00:48:56	How do you know if the size fits?	"Using meters/elbows and feelings. Balance is judged through sight and experience."	- Visual Estimation: The dominance of experience and intuition in determining balance.- Implicit Symmetry: Emphasis on right-left balance even without mathematical measurements.
01:03:19	How do you make <i>a palatto</i> (boat deck)?	- Use wood or bamboo arranged with a support circle (diameter 11-14 cm).- The distance between the circles is ± 25 cm, adjusted to the strength and weight needs.- The right and left <i>palettes</i> must be identical.	- Adaptive Geometry: Using circles with variations in diameter for strength.- Distance Concept: Spacing arrangement between components based on empirical analysis.



Table 4. Mathematical Concepts in the Making of Sandeq Lopi

Time Code	Question	Answer (SB2)	Ethnomathematical Analysis
00:42:31	Does the length of the boat affect speed?	<i>"No. The speed depends on the crafting technique, the quality of the screen, and the jockey's skill."</i>	- Functional Optimization: Focus on practical factors (design, materials, craftsmanship) rather than mathematical calculations.- Non-Linear Proportions: Boat length and speed have no fixed relationship.
00:54:08	How do we determine the height of the screen pole?	<i>*"The height of the sail mast (15-16 m) is adjusted to the maker's wishes. There is no fixed formula." *</i>	- Design Freedom: The screen's height is determined based on preference and experience, not mathematical ratios.- Contextual Adaptation: Emphasis on trial and functional needs.
01:12:30	How do you tie boat parts?	<i>"Using rattan ropes with special knots taught from generation to generation."</i>	- Symmetry and Balance: Traditional bonding techniques maintain structural balance.- Derived Wisdom: Using inherited bonding patterns without formal mathematical analysis.

Based on the exposure of the data in the table above, it can be concluded that the process of making Lopi Sandeq by SB2 shows a rich ethnomathematical practice even though it does not explicitly use formal mathematics. The concepts of measurement, symmetry, and proportion remain evident in manufacturing techniques, where visual estimation and iterative testing are key to achieving the vessel's dynamic balance and optimal speed. For example, the use of circles on the palette and the spacing between components reflect an intuitive understanding of geometry and load distribution that has evolved through hereditary experience. Cultural aspects are also inseparable: traditional bonding techniques and the selection of odd numbers (such as the number of *hunger*) are technically functional and linked to local beliefs, while material innovations such as the replacement of bamboo with wood demonstrate need-based adaptability without neglecting core structural principles (Alamsyah, A.,2023). Educationally, this process offers excellent potential as a resource for contextual learning from teaching adaptive geometry and practical measurements to material optimization, while instilling the value of rigour, team collaboration, and appreciation of cultural heritage. Thus, Lopi Sandeq is a symbol of Mandar's local wisdom and a tangible proof of how integrating traditional knowledge, innovation, and



scientific principles can create relevant and meaningful learning, both technically and philosophically.

The following is a summary of the results of the SB3 interview, which has been compiled in the form of a table, where the table is also compiled in three different parts as in SB1 and SB2, namely first, related to the Sandeq Lopi Making Process, then Mathematical Concepts in the Making of Sandeq Lopi, and finally the Cultural Values and Traditions carried out (Table 5, Table 6), then also equipped with ethnomathematical analysis.

Table 5. Sandeq Lopi Making Process

Time Code	Question	Answer (SB3)	Ethnomathematical Analysis
00:13:34	How do you measure the balance of the hull?	<i>"We don't measure. We use visual acuity and experience. Aids such as meters only mark the initial thickness (2 cm)."</i>	- Visual Estimation: Dominance of vision and practical experience.- Dynamic Balance: Adjustment based on intuition.
00:17:03	How do you determine the thickness of the keel (10 cm)?	<i>"Using hollow wood as a benchmark. Every 1 meter, holes are made with wooden nails to ensure even thickness."</i>	- Traditional Measurement: Sassusu/sassing units for markers.- Practical Iterations: Trial and error for precision.
00:24:50	What are the manufacturing steps after the hull is complete?	<i>*"Make bones (30 pieces, 25-40 cm apart) to support the floor. Then make hunger (floor) and map' (access door)."</i> *	- Adaptive Proportions: Determination of the number of bones based on strength requirements.- Functional Geometry: Partition of space for accessibility.
00:34:41	Does math measure paccong angle?	<i>"No. The angle and shape of the paccong (triangle) are determined based on intuition. The eye judges balance."</i>	- Intuitive Geometry: A triangular design without a formal formula.- Implicit Symmetry: An emphasis on visual balance.
00:55:50	What is the technique for making a palatto (sail pole)?	<i>"Palatto from bamboo was chosen because it was strong and lightweight. The ends are tapered to split the water. There is no need for additional support"</i>	- Material Optimization: Selection of bamboo based on physical properties.- Aerodynamic Geometry: Pointed shape for motion efficiency.



		<i>because the natural structure of bamboo is already strong."</i>	
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Table 6. Mathematical Concepts in the Making of Sandeq Lopi

Time Code	Question	Answer (SB3)	Ethnomathematical Analysis
01:11:40	Is school math used?	<i>"No. Math, such as triangles or squares, is not applied. The simple calculation (division of timber) is done intuitively."</i>	- Contextual Mathematics: The use of practical calculations without formal formulas.- Intuition vs Formalism: The dominance of experience.
01:04:08	How does religion affect the shape of Lopi Sandeq?	<i>"The boat parts are designed to resemble Arabic letters: Alif (sail mast), Lam (paccong), and Hu (rudder). Prayers and shaha's shahadah are recited during the installation of nails for salvation."</i>	- Geometric Symbolism: Integration of religious symbols in design.- Measurement Rituals: Prayer is an integral part of the technical process.
01:16:22	How to choose a good day to launch a boat?	<i>"Following religious teachings: choose Monday or Thursday based on the hadith of the Prophet. Not using a traditional calendar."</i>	- Contextual Time Concept: Choice of days based on spiritual values.- Value Integration: Religion as the basis for decision-making.

Based on the exposure of the data in the table above, it can be concluded that the ethnomathematical practice in the making of Lopi Sandeq by SB3 shows a unique harmony between technical logic and spiritual values. Although SB3 does not use formal mathematics, concepts such as visual estimation, adaptive proportion, and implicit symmetry are reflected in the manufacturing process, where traditional measurements (*sassusu/sassiqung*) and practical iterations are key to achieving structural precision. Cultural and spiritual aspects are deeply integrated: the shape of the boat inspired by Arabic letters (Alif, Lam, Hu) and *the ritual of ma'bacabaca* reflect not only geometric symbolism, but also the religious values that form the philosophical basis of shipbuilding. The selection of good days based on religion further emphasizes the distinctive concept of contextual time, uniting practical logic with local beliefs. From an educational perspective, this process offers broad potential as a source of contextual learning from teaching intuitive geometry and material optimization to the principle of dynamic balance while internalizing the value of rigour, patience in iteration, and respect for tradition.



Thus, Lopi Sandeq is not only a work of engineering but also a medium of life that shows how mathematical knowledge, spirituality, and local wisdom can synergize to create learning that is holistic, relevant, and full of cultural meaning (Sonni, A. F., et al 2021; Pawara, M. U., & Mahmuddin, 2023).

In the study of the construction of Lopi Sandeq, a significant finding emerged regarding the boat builders' approach to achieving balance and precision. In contrast to the modern construction practice that predominantly applies formal mathematical principles and exact calculations, the makers of Sandeq fundamentally rely on intuition honed through experience and keen visual perception as the main determinants. Although initial measurements using conventional tools such as meters may be used as a basic reference, this method does not serve as a final determining factor in optimizing boat balance. Crucial decisions are based instead on subjective and adaptive assessments that develop from their in-depth interactions with materials and contextual understanding of aquatic dynamics.

CONCLUSION

This research has revealed the depth of intuitive wisdom that is the primary foundation in constructing Lopi Sandeq by *passandeq* in West Sulawesi. Through qualitative approaches and interpretive phenomenology, we found that these traditional boats' exceptional precision and balance did not solely depend on formal mathematical applications or exact calculations. Instead, it is rooted in a deeply internalized form of non-formal knowledge: intuition, hereditary experience, and visual sensitivity honed over the years.

The *passandeq* consistently shows how their "feelings" and "visions" are crucial determinants in every stage of boat building, from selecting raw materials to determining the optimal outrigger position. This confirms that technical precision can be achieved through different cognitive pathways, where honed subjective judgments become just as valid, if not more relevant, than abstract formulas. These findings enrich ethnomathematical perspectives, showing that there are diverse ways in which humans understand and apply spatial and equilibrium principles in their cultural contexts.

This study underscores the importance of appreciating and understanding local knowledge often overlooked in the modern scientific narrative. The intuitive wisdom in making Lopi Sandeq is tangible evidence of the richness of cultural heritage that contains valuable lessons about adaptation, innovation, and harmony between humans and their environment. By appreciating this intuitive dimension, we pay homage to the *passandeq* tradition and open up opportunities to



see how emotional intelligence and sensory experience can contribute to creating effective and sustainable technology. Further research can explore how this intuitive wisdom can be integrated into the context of modern education or design.

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