Exploring Ethnomathematics: Understanding Lobachevsky Geometry through Traditional Fishing Tools of the Bengkulu People

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This research bridges a gap in ethnomathematics by exploring non-Euclidean geometry through local culture. We demonstrate that the abstract concepts of Lobachevsky geometry can be intuitively understood using *bubu*, a traditional Bengkulu fishing trap. This study enriches Indonesian ethnomathematics and provides a pedagogical framework for teaching advanced math. Analysis of the *bubu*'s internal structure reveals hyperbolic characteristics that embody the Lobachevsky Axiom of Parallelism. This axiom, which states that through a point outside a line there are at least two lines parallel to it, is visually reflected in the arrangement of the trap's blades. Our findings show that students grasp the Lobachevsky Parallelism Theorem not through formal proof, but as a conceptual discovery. They logically conclude that if the axiom allows for 'at least two parallel lines', then in hyperbolic space, the number must be 'infinite'. This cognitive process proves how cultural contexts like the *bubu* can be a powerful learning medium for visualising and understanding complex mathematical principles.

Keywords: Ethnomathematics; Bengkulu culture; Lobachevsky geometry; Axiom of parallelism; Parallel Theorem

I. INTRODUCTION

Mathematics is often perceived as an abstract discipline and detached from everyday life, a view that poses significant challenges in formal education. This perception can lead to learning difficulties among students, especially in subjects such as geometry that demand high-level thinking skills (Azmi *et al.*, 2025; Mei *et al.*, 2025; Sigit Sugiarto *et al.*, 2024). However, through an ethnomathematical approach, we can bridge the gap between formal mathematics and the cultural realities of students, showing that mathematical concepts have actually long been integrated in various local cultural artifacts (Andriani *et al.*, 2020; Azmi *et al.*, 2025; Darto *et al.*, 2024; Dini Zulaekha & Sutama, 2023; Nur *et al.*, 2020; Sigit Sugiarto *et al.*, 2024; W. Widada *et al.*, 2020c; Widada *et al.*, 2021; 2019). Research has proven this a lot, by uncovering the richness of mathematics in various cultural heritages, ranging from traditional woven fabrics such as South Sumatra's Songket which is rich in the concept of

geometric transformation, to traditional house architecture that contains the principles of building space and flat (Sari *et al.*, 2024). For example, *songket* with the Pucuk Rebung motif is a small triangle pattern that repeats identically along the fabric. That is the principle of translation. There are also those with a Cape Flower motif that creates symmetry. This motif reflects the parts of the pattern that result in a balanced and harmonious design. It is a principle of reflection. As such, *songket* is a beautiful cultural heritage, and is a visual manifestation of geometric principles. This approach not only makes mathematics more relevant and understandable but has also proven effective in improving various students' cognitive abilities, such as problem-solving skills and general conceptual understanding. Similarly, the *bubu* (fish trap) serves as an effective starting point for learning Lobachevskian geometry, facilitating students' understanding of the concepts and principles of non-Euclidean geometry (Rezaei *et al.*, 2022; Sukestiyarno *et al.*, 2023a; W. Widada *et al.*, 2020a; Widada & Herawaty, 2023).

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Therefore, research focusing on the traditional fishing tool *bubu* is important and urgent. It is not only an attempt to document cultural heritage as an object of historical value, but also to uncover and preserve the embodiment of complex mathematical thinking (Dini Zulaekha & Sutama, 2023; Kobandaha *et al.*, 2025; Sigit Sugiarto *et al.*, 2024; Suyitno *et al.*, 2020) and intuitive from artisans and fishermen. This knowledge, which may have been overlooked, has great potential to enrich teaching materials and change people's perceptions of the application of mathematics in everyday life.

The urgency of this research is further strengthened by its potential to address one of the greatest challenges in mathematics education, namely the understanding of highly abstract concepts of non-Euclidean geometry (Skrodzki, 2020; Sukestiyarno *et al.*, 2023b). Since its emergence, non-Euclid geometry has shaken up the status of Euclid's geometry that was previously considered the only truth, proving that there are other geometric systems that are equally logical and consistent. However, its counter-intuitive nature makes material such as Lobachevsky's Geometry very difficult to teach and learn through conventional methods. This is where ethnomathematical approaches offer innovative solutions. A key study by Herawaty *et al.* (2020a) found that the cultural artifact of *bubu*, with its distinctive woven structure, could be an effective medium for helping students understand the axiom of Lobachevsky's parallelism—a concept that was a fundamental differentiator from Euclid's geometry. These findings are reinforced by other research showing that the use of local content, such as glutinous rice cakes, also successfully helps students understand the properties of triangles in Lobachevsky Geometry (W. Widada *et al.*, 2020b; W. Widada *et al.*, 2020a). Furthermore, it has been quantitatively proven that learning non-Euclidean geometry through an ethnomathematical approach significantly improves students' spatial abilities compared to conventional learning. Thus, this research aims not only to expand the scope of ethnomathematical studies to non-Euclidean domains, but also to develop a pedagogical framework that can make advanced mathematical concepts more concrete and accessible to students.

Ethnomathematical studies have historically shown a significant focus on the integration of Euclid's geometric concepts with the rich local cultural heritage (Abay & Parola, 2024; Dini Zulaekha & Sutama, 2023; Payadnya *et al.*, 2025; Roza *et al.*, 2020; S Sugiarto *et al.*, 2024; Sigit Sugiarto *et al.*, 2024). This exploration is not only limited to the identification of simple geometric patterns but also highlights how cultural products can serve as solid foundations for more in-depth mathematical learning. For example, a study of the traditional snack *lupis* cake managed to identify the various elements, characteristics, and properties of the triangle in Lobachevsky's geometry (W. Widada *et al.*, 2020a). This study shows that in Lobachevsky's geometry, a triangle is not an ordinary flat shape. In contrast to Euclid's geometry where the number of angles is always 180 degrees, the number of angles in the Lobachevsky triangle is less than 180 degrees. This concept can be understood more easily through the objects around us. It is **Sticky Rice Cake** (*lupis*) which can be used to explain the concept of a triangle with a total angle of less than 180 degrees. Furthermore, other research also found geometric concepts, both plane and space, in traditional architecture, such as Sewu Temple (Dini Zulaekha & Sutama, 2023) which contains the elements of triangles, squares, trapezoids, and rectangles (plane geometry), as well as cubes, blocks, tubes, and square pyramids (spatial geometry). Similarly, geometric concepts are found in Javanese traditional ceremonial equipment (Primaniarta & de Mattos, 2022). This ethnomathematical approach successfully maps the relationship between culture and mathematics education, showing that cultural artifacts do not only have aesthetic value (Abah *et al.*, 2021; Ghuli & Mahmoud, 2024; Hou, 2024; Zhang *et al.*, 2023), but also contains mathematical principles that can be used to enrich the learning curriculum (Prahmana *et al.*, 2024; Rubio, 2016). This cultural context becomes an effective bridge to help students better understand abstract mathematical concepts, making them contextual and relevant.

However, although the research of Euclid geometry in a cultural context is sufficiently developed, there is a fundamental gap in ethnomathematical studies that specifically links cultural practices to non-Euclid geometric concepts, such as Lobachevsky's geometry (D. Herawaty *et al.*, 2020a; 2020b; Nugroho *et al.*, 2021; 2022; Sukestiyarno

et al., 2023b). Since the advent of non-Euclidean geometry in the 19th century, the status of Euclid Geometry that was previously considered the only absolute truth has become problematic, opening up space for a new understanding of space and form. The fundamental difference between these two geometries lies in the parallel postulate, where Euclid's geometry allows only one parallel line, while Lobachevsky's geometry (a hyperbolic geometry model) allows for an infinite number of parallel lines through a single point outside that line (Lapin, 2020; Pryshliak, 2024; Walkden, 2019; Wahyu Widada *et al.*, 2020b). This knowledge gap creates significant research opportunities to explore whether principles aligned with Lobachevsky's Geometry can be found in traditional cultural artifacts. Some contemporary ethnomathematical studies have begun to bridge this gap by developing learning models, as seen in studies that design non-Euclid geometry learning trajectories through ethnomathematical approaches to improve spatial ability (Sukestiyarno *et al.*, 2023b). This effort demonstrates a recognition of the importance of diversifying the focus of ethnomathematical research from mere Euclid geometry, towards broader explorations, such as non-Euclid spaces, which may be manifested in curved patterns or other cultural structures that do not follow the rules of classical parallel postulates. As such, the application of these principles in traditional cultural artifacts is still a very limited area and requires further exploration.

This critical knowledge gap, between the dominant ethnomathematical study of Euclid Geometry and the untapped non-Euclidean Geometry domain, forms the main cornerstone of this research. This focus is rooted in the hypothesis that cultural artifacts are not only tied to the rules of classical geometry, but also potentially contain principles that are in harmony with Lobachevsky's Geometry. For example, the structure and weaving patterns of the *bubu*, a traditional fishing tool from Bengkulu-Indonesia, are assumed to be not only manifestations of Euclid's geometry which have been widely researched, as found in woven fabrics or traditional architecture (Chen *et al.*, 2024; Eko, 2917; Sari *et al.*, 2024), but also indicates the existence of a hyperbolic concept. Thus, this research aims to bridge the gap of understanding that exists (Azmi *et al.*, 2025; Gholami *et al.*, 2023), and integrate ethnomathematics with the more complex domains of non-Euclidean geometry (Fouze & Amit,

2021; Hernawati *et al.*, 2024; Nursyahidah *et al.*, 2025a; Sudirman, 2020; Sunzuma, 2021; Wulandari *et al.*, 2024).

To achieve this goal, this study poses a central question: how are the concepts of Lobachevsky geometry, particularly as it relates to parallel postulates, implicitly manifested in the structure and pattern of *bubu* weaving from an ethnomathematical perspective? This question provoked in-depth exploration, given that Lobachevsky's Geometry, as one of the non-Euclid models of geometry, challenged Euclid's parallel postulate which stated that there is only one parallel line (Beeson *et al.*, 2015; Gray, 2015; Heyfetz, 2021). In contrast, Lobachevsky's geometry allows for the existence of infinitely number of parallel lines through a single point beyond a given line, a principle that may be reflected in the curvature or complex weaving of the *bubu*. This approach is in line with contemporary efforts to diversify the study of ethnomathematics (D. Herawaty *et al.*, 2020b), goes beyond traditional focus and explores how culture can be a vessel for teaching more abstract and complex mathematical concepts, as seen in research that uses ethnomathematics to overcome difficulties in understanding systems of linear equations (Wahyu Widada *et al.*, 2020d). By identifying the manifestations of Lobachevsky Geometry in cultural artifacts such as *bubu*, this research not only enriches the study of ethnomathematics in Indonesia but also offers an innovative pedagogical approach to teaching non-Euclidean geometry through culturally relevant contexts, opening up new insights into the relationship between mathematics and local cultural heritage. Therefore, the question of this research is, 'How are Lobachevsky's concepts of geometry, particularly as they relate to parallel postulates, implicitly manifested in the structure and patterns of traditional *bubu* fishing gear from an ethnomathematical perspective?'.

II. MATERIALS AND METHOD

A. Research Design

This study uses a qualitative approach with the type of ethnographic exploration research (Anriana *et al.*, 2023; Nurjanah, 2021). The main focus of this research is to explore the mathematical concepts contained in the local cultural context (Bengkulu-Indonesia), namely in the traditional fishing tool *bubu*. The aim is to describe and analyse in depth

the mathematical practices found in the process of creation, use, and patterns found in *bubu* from an ethnomathematical perspective.

The subjects of this study were artisans and fishermen who actively use *bubu* fishing gear in the coastal area of Bengkulu, Indonesia. Subjects were selected using purposive sampling, selecting key informants with in-depth knowledge and experience in *bubu* making and use.

The research procedure includes several main stages:

➢ **Initial Stage (Exploration):** This stage involves preliminary studies to identify relevant research communities and subjects. The researcher conducted initial observations and informal approaches to the community.

➢ **Field Stage (Data Collection):** In this stage, the researcher collects data through various techniques, as described in the following sub-sections.

➢ **Data Analysis and Interpretation Stage**: The collected data is analysed to find relevant mathematical patterns, themes, and concepts. The researchers then interpreted the findings to compile an ethnomathematical description of *bubu*.

B. Data Collection Techniques

Data collection in this study was carried out through triangulation, which combines three main techniques to ensure the validity and reliability of the data. The techniques used are:

➢ **Participatory Observation**: Researchers directly engage and observe the process of making and using *bubu* by artisans and fishermen. This observation aims to understand everyday practices and the way they apply mathematical concepts.

➢ **In-Depth Interviews**: Interviews were conducted with the research subjects to explore their understanding of the concepts of shape, size, ratio, and geometry that they intuitively used in the creation of *bubu*.

➢ **Documentation**: Collection of supporting data is carried out through photographs, videos, sketches, and field notes that record geometric shapes, patterns, and *bubu* structures.

C. Data Analysis Techniques

Data analysis is carried out interactively and continuously since data collection begins. This analysis aims to identify and describe ethnomathematical concepts, particularly those related to Lobachevsky geometry and parallel postulates, which are implicitly used by society in the creation of *bubu*. The data analysis steps refer to the Miles and Huberman model (data reduction, data presentation, and conclusion drawn) (Miles *et al.*, 2013), and continued with the following three stages of analysis.

➢ **Content Analysis**: Identify keywords, themes, or mathematical patterns in interview transcripts or documents.

➢ **Thematic Analysis**: Identify important themes and motives from interview and observation data.

➢ **Pattern Recognition**: Identifies mathematical patterns in the construction or object being studied.

III. RESULT AND DISCUSSION

This research aims to identify and analyse the application of **Lobachevsky Geometric principles** in the design and construction of **bubu**, a traditional fishing gear used by the people of Bengkulu. In particular, we explore how the physical properties of *bubu*-forming elements, such as skewers, inherently reflect the concepts and axioms of these non-Euclidean geometries.

The results show that **the internal shape of Bubu has the characteristics of a hyperbolic wake**, which is the basis of Lobachevsky's geometry. These findings are supported by direct observation and visual documentation (see Figure 1) and reinforced by qualitative data from in-depth interviews. Interviews with key respondent (S) revealed that the way the skewers forming the *bubu* is arranged and arranged basically **builds the Lobachevsky Axiom of** Parallelism.

A. Axiom of Lobachevsky's Parallelism in Bubu Construction

Lobachevsky's Axiom of Parallelism states that, 'through a point outside a line, there are at least two lines parallel to it'. In the context of *bubu*, the builder's skewers serve as 'lines' in hyperbolic space. This arrangement of the skewers creates a structure whereby from one particular point in the skewer,

more than one 'skewer line' can be drawn that will never meet any other 'skewer line', effectively forming a non-Euclidean space.

Further analysis will be presented through the transcription of in-depth interviews between researchers (P) and respondents (S) who provide empirical evidence of how the people of Bengkulu, intuitively or practically, have applied these principles of complex geometry in their cultural heritage.

S Identifying Problems with Local Cultural Contexts (Activity-1)

In Activity-1, students observe traditional fishing gear *bubu* directly, then identify traditional fishing gear related to the axiom of line alignment in Lobachevsky geometry. *Bubu* can be seen in Figure 1.
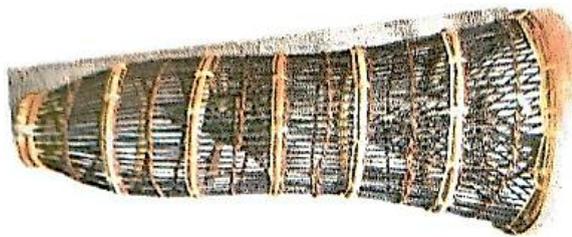

Figure 1. Traditional Fishing Gear *Bubu*
(Source: Author)

Figure 1 is a traditional fishing gear *bubu* identified by students S. Students are very familiar with traditional tools, so students can identify them well. This is supported by the results of the interview with S by P, as follows.

Q: Good morning. Thank you for taking the time to do this interview. We will discuss your interesting discoveries regarding the geometry of the Lobachevsky Axiom of Parallelism, which you find in the context of the traditional fishing gear 'bubu'. Can you describe your invention in detail?

S: Good morning, sir. It was a pleasure to share my observations. I observed the structure of 'bubu' made of woven skewers. In particular, I focus on the spatial relationships between the skewers that make up the 'bubu' skeleton. You can see it in Figure 1. I found the geometric patterns interesting.

This interview excerpt provides confirmation of what the students have done in Figure 1. This means that students can identify the *bubu* fishing gear, which is a building made of

woven sticks, and S is able to connect spatially between the sticks that make up the *bubu* skeleton. This shows that S identifies the problem of Lobachevsky's alignment axiom through the context of the traditional fishing gear *bubu* well.

S Representing Problems (Activity-2)

The student activity in Activity-2 is that student S is able to visualise the g-line on the *bubu* that he chooses from one of the sticks located at the base of the *bubu*. This can be seen in Figure 2.

Figure 2. One skewer at the base of *bubu* (line g)
(Source: Author)

Figure 2 is that the student represents a *bubu* as a wake made of many skewers woven in a curved manner and each of the lids is not intersecting. Student S also chose one skewer at the base of the *bubu* which he called the g-line. This is supported by the following interviews.

Q: Can you explain the pattern?

S: Let's imagine a simple 'bubu'. It is made of many curved woven skewers where each of the skewers does not intersect. At the base of the 'bubu' there are skewers that can be called the main support, let's call it the g line (see Figure 2.).

Based on this interview excerpt, it was confirmed that students were able to accurately represent Lobachevsky's parallel axiom problem through the context of the traditional *bubu* fishing tool. The curved design of this funnel-shaped fish trap resembles a cone. The trap is woven from bamboo strips that curve inward. Its function is to trap incoming fish and prevent them from escaping. The interlocking woven structure that supports this curved shape makes the trap strong and sturdy for catching fish in rivers. Thus, this fish trap is a clear example of the combination of the art of weaving and the principles of hyperbolic geometry.

S Making a Completion Plan (Activity-3)

Activity-3 is that students can develop a problem-solving plan. That is, S takes the point P that is above, connecting it to the position of the g line. He indicated a plan to create a line that passed through point P beyond the g line. This can be seen in Figure 3.
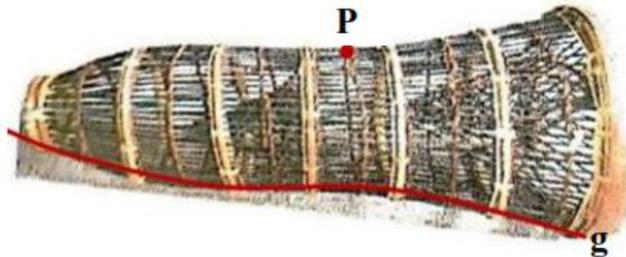

Figure 3. One skewer (g-line) at the base and Point P at the top of the *bubu* (Source: Author)

Figure 3 shows that student S was able to make a plan to solve the problem of the Lobachevksy equivalence axiom by using the context of *bubu* well. This is supported by the results of the interview, as follows:

Q: What would you do about the skewer pattern on 'bubu'?

S: Based on the skewers on bubu, …. and e… if we are going to take one main support skewer, and the point P at the top of the 'bubu'. Let's try how the stick that passes that point is.

Excerpts from the interview and Figure 2 confirm each other that S was able to make a plan to solve the problem of Lobachevsky's alignment axiom through the context of the traditional fishing gear *bubu* precisely.

S Implementing the Plan (Activity-4)

In activity 4, students executed a problem-solving plan about the Lobachevsky axiom of harmony through the context of the traditional fishing gear *bubu*. In this activity, students can determine that the number of rows is parallel to a particular line. This can be seen in Figure 4.
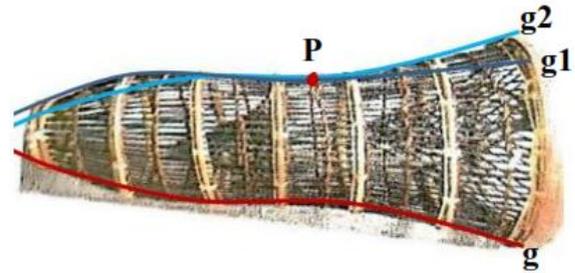

Figure 4. The skewers at the base (g-line) are aligned with two skewers that pass through the P point (g1 and g2 lines) (Source: Author)

Figure 4 shows that student S was able to implement a plan to solve the problem of the Lobachevksy alignment axiom using the context of *bubu*. This is supported by the results of the interview, as follows:

Q: OK… What's next?

S: In accordance with what I said earlier that we took one main support skewer at the base, and the dot at the top of the bubu, I found that there were at least two other skewers that were parallel to the base skewer, without ever intersecting. This is in contrast to Euclidean geometry, where there is only one parallel line that can be drawn through a point outside the other lines.

Q: So, you find that in the context of the 'bubu' structure, Euclid's Axiom of Parallelism does not apply?

S: Right. The structure of 'bubu' shows clear examples of non-Euclidean geometry, in particular Lobachevsky's hyperbolic geometry.

Q: What do you mean?

S: Yes, I found an example of the Lobachevsky parallelism axiom, which states that through a point outside the line, there are at least two lines parallel to that line. It was the result of my observation of 'bubu' that supported the axiom of Lobachevksy's parallelism.

The interview excerpt confirms Figure 4 that S was able to implement a plan to solve the problem of Lobachevsky's Parallelism through the context of the traditional *bubu* fishing gear. That is, S states through the point at the top of the *bubu* at least two other skewers are found that are parallel to the skewers at the base of the *bubu*.

S Evaluating Problem-Solving (Activity-5)

In Activity-5, students evaluate the solution of the problem of Lobachevsky's alignment axiom with the context of

traditional fishing gear *bubu*, by retesting directly, about the alignment of two skewers above the *bubu* with a single line at the bottom of the *bubu*. This is the alignment of the lines in Lobachevsky's Geometry that can be seen in Figure 5.
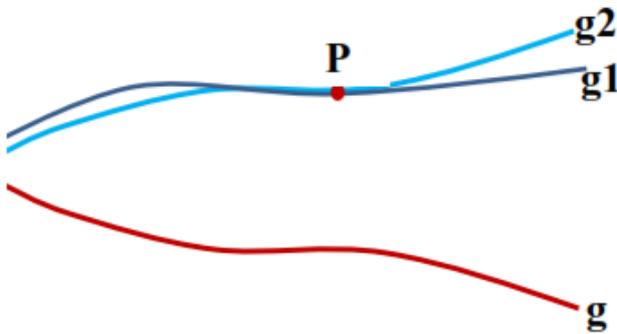

Figure 5. The two lines g1 and g2 pass point P beyond the g line (Source: Author)

Figure 5 shows that student S is able to evaluate the solution of the problem about the axioms of the Lobachevsky equation by using the context of *bubu* in the form of a visual image. This is supported by the results of the following interview.

Q: Can you explain more about how the structure of 'bubu' represents hyperbolic geometry?

S: The woven structure of the skewers on 'bubu' creates a curved surface. Lobachevsky's geometry, in contrast to Euclidean geometry which applies to flat surfaces, applies to negatively curved surfaces. The curved surface of the 'bubu' allows the existence of more than one parallel line passing points beyond the other lines. The skewer on the 'bubu' can be considered as a line on the surface of this curve.

Based on the interview excerpt, student S confirms Figure 5 that the woven structure of the skewer on *bubu* creates a negative curved surface that makes the existence of more than one parallel line pass through the point outside the other line. Students S evaluated the solution of the Lobachevsky Parallelism problem through the context of the traditional *bubu* fishing gear and produced a spatially clear visualisation of the axiom of Lobachevsky Parallelism.

S Concluding (Activity-6)

Activity-6 is the last activity in the learning path of the Lobachevsky parallelism axiom using the context of the traditional fishing tool *bubu*. In this activity, students draw conclusions about Lobachevsky's axioms in the form of mathematical statements. It can be seen in Figure 6.

Figure 6. Conclusion from S
(Source: Author)

Figure 6 shows that student S can make a statement about Lobachevsky's axiom of parallelism, i.e., through the point P outside the g line there are two lines g1 and g2 that are parallel to the g line. This is supported by the results of the following interview.

Q: What can you conclude from your experiments on the Lobachevksy alignment axiom using the context of the 'bubu' fishing gear?

S: I can draw the conclusion that, 'Through a single point P outside the g-line there are at least two lines g1 and g2 parallel to g'.

Based on Figure 15 which is confirmed by the interview excerpts, students are able to draw conclusions about the Axiom of Lobachevsky Parallelism through the context of traditional fishing gear *bubu* into the formal Axiom of Lobachevsky Parallelism.

Thus, Lobachevksy's Axiom of Parallelism is obtained: Through one point P outside the g-line there are at least two lines g1 and g2 that are parallel to g.

B. Lobachevsky's Parallelism Theorem

This study analyses how **Lobachevsky's Parallelism Theorem** is understood and internalised by students, especially in the context of learning Non-Euclidean Geometry. In contrast to the intuitive Euclidean Geometry, Lobachevsky's Geometry introduces concepts that challenge conventional understanding, of which the Parallelism Theorem being one of the most prominent examples.

The results of this study show that Lobachevsky's Parallelism Theorem is often accepted by students as a

finished statement or **a corollary** of its basic axiom. This theorem reads: Through the point P outside the g line, there are an infinite number of lines parallel to the g line. This is a direct consequence of **Lobachevsky's Axiom of Parallelism** which states that there are 'at least two parallel lines'.

Further analysis of in-depth interviews revealed that students understood this theorem not through a formal deductive process, but as a conceptual discovery. They concluded that if there is more than one parallel line (axiom), then logically there must be **an infinite number of** parallel lines, given the properties of hyperbolic space. This process of understanding will be discussed in detail, including the challenges students face in imagining these non-intuitive concepts.

An in-depth analysis of interviews between Researcher (P) and Respondent (S) reveals a unique process of understanding **Lobachevsky's Parallelism Theorem**. The results of the analysis show that S found and proved this theorem based on the results of previous activities on **Lobachevsky's Axioms of Parallelism** using the context of the *bubu* fishing culture.

The understanding of S does not come from the flow of formal proof, but from **conceptual discovery**. This interview highlights how S concludes that if the axiom allows 'at least two lines to be parallel', then logically and visually in hyperbolic space, the number of lines must be **infinite**. This cognitive process shows how the subject understands the consequences of a non-Euclidean axiom without having to go through complicated formal proofs, providing valuable insight into how non-intuitive mathematical concepts can be internalised. The results of the in-depth interview analysis are as follows:

S Representing Problems (Activity-2)

The student's activity is that student S is able to visualise the lines that pass through the point P outside the g line and parallel to g. This can be seen in Figure 7.

Q: How do you find that there is an infinite number that passes through the point P beyond the g line and the line parallel to g.

Q: Okay sir... see the illustration in Figure 7. Suppose the point P and the line g are given with P ∉ g. Consider Figure

7. It will be proved that through the point P there is an infinite line parallel to g. It is sufficiently evident that m (∠XPQ = m(∠YPQ) and (∠XPQ & ∠YPQ) are blunt.
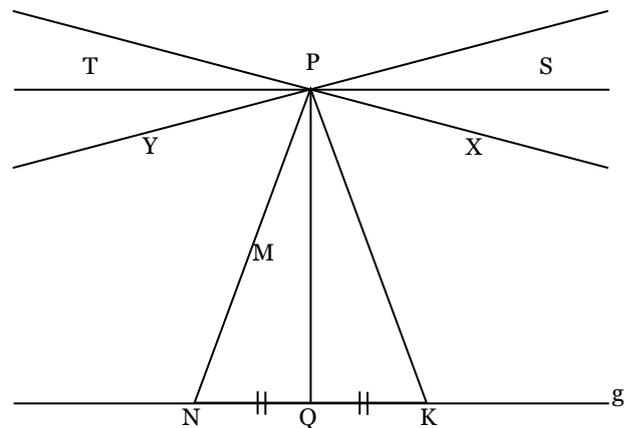

Figure 7. Alignment of Lines
(Source: Author)

S Making a Completion Plan (Activity-3)

Activity-3 is that students can make a problem-solving plan about proving that the lines that pass-through point P are parallel to line g. Here is a snippet of the interview:

Q: OK continue!

S: Suppose then there is a ray cutting g in N and take the point K with (NQK) so that according to the axiom (S-Sd-S). The result is obtained, then it must be an input.$m(\angle YPQ) > m(\angle XPQ)\overrightarrow{PM}\angle YPQ \simeq \angle MPQ\overline{NQ} = \overline{KQ} \triangle QNP \simeq \triangle QKPm(\angle MPQ) = m(\angle KPQ) = m(\angle XPQ)\overline{PX}\overline{PK}$

S Implementing the Plan (Activity-4)

In activity 4, students executed a problem-solving plan about the possibility of other lines that are parallel to g and those lines that pass through the point P. The following is an excerpt of the interview.

Q: Okay. What next?

S: Further that it is impossible because it does not intersect g, so the assumption m in the same way it can be shown that the correct $m(\overline{PX}\angle YPQ) < m(\angle XPQ)$ is incorrect.$\angle YPQ) \not< m(\angle XPQ). Thus, \angle XPQ \simeq \angle YPQm(\angle XPQ) = m(\angle YPQ)$

Q: OK.

S: Next it will be shown that and taper corners. If the right angle is right, then the XPY must be linear, even though the XPY is not linear. So instead of right angles

$\angle YPQ \angle XPQ \angle XPQ$ & $\angle YPQ \angle XPQ$ & $\angle YPQ$ ➔ $\angle XPQ \neq 90o$ and $\angle YPQ \neq 90o$.

Q: Okay...

S: Suppose and the blunt angle or $\angle XPQ \angle YPQ \angle XPQ > 90o$ and $\angle YPQ > 90o$, then it results that the perpendicular line PQ in P and is loaded by d (this is opposite to the parallel g. This means that the approximation $\overleftrightarrow{TS} \angle XPY) \overleftrightarrow{TS} of \angle XPQ > 90o$ and $\angle YPQ > 90o$ is wrong, it must be $\angle XPQ$ and $\angle YPQ$ not the blunt angle.

S Concluding (Activity-6)

In this activity, students S are able to draw conclusions that there are an infinite number of lines that pass-through P that are parallel to g.

Q: What is your conclusion?

S: Based on these arguments, it is concluded that $\angle XPQ$ and $\angle YPQ$ are pointed angles. Therefore, then and the two angles are taper angles, consequently //g, //g, and //g, and many other lines that pass through the point P parallel to g. The conclusion is that there are an infinite number of lines that pass-through P that are parallel to g. $m(\angle XPQ) = m(\angle YPQ) \overleftrightarrow{TS} \overleftrightarrow{YP} \overleftrightarrow{XP}$

Based on the analysis, the student (S) found and proved the **Lobachevsky Parallelism Theorem** conceptually. Using the context of *bubu*, S represents the problem, plans, and executes the proof. He concluded that if **Lobachevsky's Axiom of Parallelism** allows 'at least two parallel lines', then logically and visually, there must be **an infinite number of** parallel lines, because the corners must be tapered, not right or dull.

To strengthen the study, an in-depth interview was conducted based on the perspective of the creator/craftsman of the tool. Further analysis of the interview with the craftsman *bubu* revealed intuitively and implicitly that the structure of the tool was in line with the principles of Lobachevsky's geometry. Craftsman explains how they deliberately made bamboo blades curve inward to create a space that allows fish to enter but cannot escape. Without them realising it, it is a process that creates hyperbolic space. The selection of materials and methods of placement of the blades is the result of hereditary knowledge that effectively applies the principle of two or more parallel lines. This insight reinforces the finding that *bubu* is representative of cultural artifacts and a complex repository of mathematical knowledge. Notice the snippet of the researcher's interview (call it R) with the craftsman *bubu* (call it C).

R: Can you tell us how you first learned to make this bubu?

C: I learned from my parents, it has been passed down from our grandparents. The key is that in bamboo blades we often refer to them as 'buds'. It is mounted curved inward, not straight. If it is straight, the fish will easily come out.

R: What makes the blades curve?

C: The bamboo is selected that is young, and then when installed, it is forced to curve slightly inwards. Then, tied up. When viewed from the inside, the blades look like they will not meet, even though the ends are both going inward. It is intended so that the fish that have entered cannot come out again.

Based on the interview snippets, the craftsman intuitively applied Lobachevsky's geometric principles. They create lines (i.e. bamboo blades) that are parallel but curved. That is to form a hyperbolic space. This knowledge is passed down through generations to prove that complex mathematical understandings are often embodied in cultural practice, long before the concept was formally formalised academically. It can therefore be concluded that complex mathematical knowledge is often embodied in traditional cultural practices. Craftsman intuitively applied the principles of non-Euclidean geometry, in this case Lobachevsky geometry. It was without formal knowledge. They understood that by making the bamboo slats curve inward, they created a space where parallel lines would never meet, a key concept in hyperbolic geometry. This proves that *bubu* as a traditional fishing tool has become a cultural artifact that holds a deep understanding of mathematics, especially Lobachevksy geometry.

This research successfully bridges fundamental gaps in ethnomathematical studies by shifting the focus from Euclidean geometry to the less explored realm of non-Euclidean geometry. In particular, this study proves that abstract concepts of Lobachevsky geometry can be identified and understood intuitively through the context of the local culture, namely *bubu*, a traditional fishing gear from Bengkulu. These findings not only enrich the study of ethnomathematics in Indonesia but also offer an innovative

pedagogical framework for the teaching of challenging advanced mathematical concepts. This is a novelty from the results of previous research such as the learning trajectory of Non-Euclid Geometry (Nugroho *et al.*, 2021; Sukestiyarno *et al.*, 2023b).

The results of the analysis show that the internal structure of the *bubu* has the characteristics of a hyperbolic build, which inherently embodies **the Lobachevsky Axiom of** Parallelism. This axiom, which states that 'through a point outside a line, there are at least two lines parallel to it', is visually and empirically reflected in the arrangement of the skewers that form the *bubu*. This is a state-of-the-art of the previous ones such as (Sukestiyarno *et al.*, 2023b; W. Widada *et al.*, 2020a; Wahyu Widada *et al.*, 2020b) Respondent(s) accurately identified how the skewers function as 'lines' in the *bubu* hyperbolic space. From a single point (P) above the *bubu*, more than one 'skewer line' (g1 and g2) can be drawn that will never meet the baseline (g). This shows that **Euclid's Axiom of Parallelism** does not apply in the context of *bubu* structure. These observations confirm how the people of Bengkulu, both intuitively and practically, have applied these principles of complex geometry in their cultural heritage.

Furthermore, this study reveals that the student's (S) understanding of **the Lobachevsky Parallelism Theorem** is not the result of formal proof. This is a novelty compared to previous research (Agusdianita *et al.*, 2021; Dewi Herawaty *et al.*, 2020; Kobandaha *et al.*, 2025; Mlambo & Sotsaka, 2025). On the contrary, S discovered and proved this theorem based on the results of his previous activity in identifying Lobachevsky's Axiom of Parallelism using the context of *bubu*. S accepts this theorem as a finished statement or *a corollary* of its basic axiom. He concludes that if the axiom allows for 'at least two parallel lines', then logically and visually in hyperbolic space, the number must be 'infinite'. This cognitive process shows how cultural context can be an effective bridge to understanding the consequences of a non-Euclidean axiom without having to go through complicated formal proofs. S independently represents the problem, plans, and executes the proof. S argues that m($\angle XPQ$ = m($\angle YPQ$) should be a pointed angle, not a right or blunt. He concluded that the assumption of right angles ($\angle XPQ \neq 90°$ and $\angle YPQ \neq 90°$) as well as blunt

angles ($>90°$) were wrong. Thus, the true is a taper angle, implying that there are an infinite number of parallel lines that can be drawn through the point P outside the g line.

These findings are particularly relevant to the challenge of modern mathematics education, which is to make abstract concepts such as non-Euclidean geometry more concrete and accessible. Since its emergence, non-Euclidean geometry has shaken up the status of Euclid's geometry which was previously considered the only truth. Its *counter-intuitive nature* makes this material difficult to teach through conventional methods. This research shows that ethnomathematical approaches offer innovative solutions to these challenges. By integrating ethnomathematics and non-Euclidean geometry, this research offers a solution to overcome learning difficulties and the perception that mathematics is a discipline detached from everyday life (Lubis *et al.*, 2021; Nursyahidah *et al.*, 2025b; Widada & Herawaty, 2022). This pedagogical strategy has proven to be effective in improving cognitive skills, such as conceptual comprehension and spatial reasoning, which are urgently needed in mathematics learning. Thus, *bubu* serves not only as a cultural artifact, but also as a powerful learning medium that visualises advanced mathematical principles hidden in local cultural heritage.

This research shows that the concept of Lobachevsky Geometry can be understood through the context of local cultures such as *bubu*. Students can discover and prove the parallelism theorem conceptually, rather than formally. This approach is effective in overcoming learning difficulties and making non-Euclidean abstract concepts more concrete, proving that *bubu* is a powerful learning medium.

Although this study shows the great potential of *bubu* as a learning medium, the specific focus on cultural artifacts from Bengkulu may limit the generalisation of the findings. It is important to recognise that these findings may not directly apply to other cultural contexts or artifacts that contain different non-Euclidean geometric principles. Therefore, further research can expand this scope. It is an exploration of the discovery of Lobachevksy geometric concepts and principles from other cultural artifacts, and from different regions.

IV. CONCLUSION

This study concludes that the concepts and principles of Lobachevsky Geometry can be taught effectively through an ethnomathematical approach using the local cultural context of *bubu*. The results of the analysis show that students can find and prove the Parallelism Theorem conceptually, not through formal proof. This ability, which is a new finding, shows that this approach is effective in overcoming learning difficulties and making abstract non-Euclidean concepts more concrete and relevant. The implication is that *bubu* can function as a powerful learning medium. It is suggested that future research explore other cultural artifacts to discover the principles of non-Euclidean geometry, which are open problems for the development of culturally relevant curricula.

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