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Ethnophysics Analysis of Traditional *Patil Lele* Game: Unveiling Physics Concepts in Local Wisdom

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Abstract

Local wisdom is integral to a community's cultural identity, encapsulating knowledge, values, and practices passed down through generations. The traditional game of *Patil Lele*, rich in cultural significance, also serves as a valuable educational tool for exploring fundamental physics concepts. This study aims to analyze the physics principles inherent in the *Patil Lele* game and identify optimal techniques for achieving maximum throwing distance. The research used a quantitative descriptive method; Data were collected through interviews and observations and supported by a thorough literature review. The findings reveal that the game embodies key physics concepts, including parabolic motion, Newton's laws, the moment of force, momentum, and impulse. Moreover, three effective techniques for enhancing throwing distance were identified. This research underscores the importance of applying physics concepts to enhance traditional games, enriching educational value and preserving cultural heritage.

Keywords: Ethnophysics, *Patil Lele*, Game Technique, Physics Local Wisdom

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² INTRODUCTION

Physics is a branch of natural science that studies natural phenomena based on existing rules, theories, principles, and laws (Maghfiroh & Kuswanto, 2021). Physics is a fundamental science that needs to be studied. However, many students have difficulty learning physics. This fact is because physics is an abstract science. Some physics materials are difficult to visualize and are not intuitive (Handayani, et al., 2019). Physics can provide scientific and in-depth explanations of the principles underlying techniques and practices in local wisdom, showing how traditional knowledge is often aligned with formally studied scientific concepts.

There needs to be media or teaching aids that can explain physics concepts in an interesting way in learning. Local wisdom plays an important role in shaping the identity of a community, because it reflects the knowledge, values, and practices that have developed from generation to generation in a region. This includes traditions, beliefs, customs, and traditional games that are characteristic of the local community. The existence of local wisdom is not only a cultural heritage, but also a foundation for the daily lives of the community (Nurmasitah et al., 2022). According to Rumiati et al. (2021) Traditional games have many benefits, including training children's creativity, controlling emotions, and social intelligence, bringing children closer to nature, developing children's motor skills, and so on. Thus, it is very appropriate to integrate the concept of physics in games into learning to get concrete examples and more meaningful learning.

One form of local wisdom that can be associated with physics learning is the *Patil Lele* game. *Patil Lele*, which is also known by other names such as *Gatrik*, *Tak Kadal*, or *Bethik* in the areas around Yogyakarta and Central Java (Wibowo, 2017; Rohmawati et al., 2019). This game uses two wooden sticks of different sizes.

The short wood is placed on a small hole in the ground, called a "wok," or on two bricks. This game is a real example of the concept of parabolic motion. In addition, other physics concepts such as Newton's laws and momentum can also be observed in this game, because the interaction between the stick and the short wood involves force, acceleration, and changes in momentum. Thus, *Patil* not only preserves local culture but also provides an effective learning method to teach physics concepts to students (Rohmawati et al., 2019).

Jamalludin et al. (2021) found that each stage in the *Patil* game is an activity related to physics concept. The traditional *Patil* game can be integrated in developing physics learning tools. In addition, Nurmasyitah's research shows that the *Patil* game can be integrated into learning parabolic motion material (Nurmasyitah et al., 2022). Meanwhile, in a study conducted by Dani, it was found that integrating traditional games such as *Patil* in physics learning has very good potential to improve students' understanding of physics concepts (Dani et al., 2022).

There are several studies that have discussed the concept of physics in the *Patil* game. However, most of them only focus on parabolic motion material. In this research, the *Patil* game will be discussed in more depth involving several physics concepts including Newton's laws as well as momentum and impulse. Not only that, this study will also compare the *Patil Lele* playing technique that is rarely discussed by previous studies. So, from the explanation related to the relationship between local wisdom and its physics concept, this research aims to analyze the physics concept in the traditional *Patil Lele* game in East Java.

METHOD

The type of research is quantitative descriptive. Descriptive quantitative research is conducted to describe the characteristics of a population or phenomenon being studied using numerical data. The data collection method is carried out by literature study, observation, interviews and documentation in the Surabaya area, East Java. Data collection with literature study aims to obtain information and study more deeply related to the *Patil Lele* game. Observations are carried out directly in the field by observing the *Patil Lele* game. The variables that influence this research are the angle of hitting the wood so that the small wood bounces into the air and the strategy or way of playing the *Patil Lele*. The research design flow is shown in Figure 1 (adapted from Rumati et al., 2021).

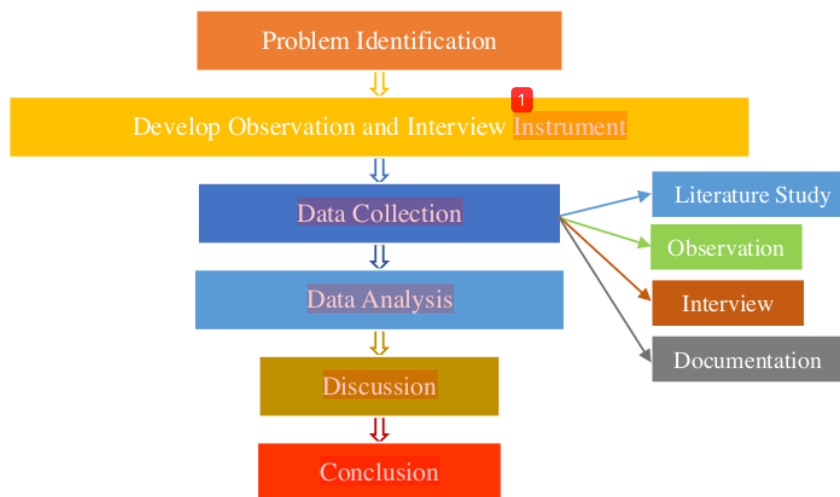


Figure 1. Research Design

Interview activities are carried out to obtain information related to ethno physics in the *Patil Lele* game. Interviews are conducted with *Patil Lele* players because they already know how to play and maintain the *Patil Lele* game as local wisdom so that they can explain the phenomena in the *Patil Lele* game. Interviews are conducted with 8 people with different age levels, namely children, adults, and parents. It is hoped that with the difference in age, various information and perspectives can be known from different points of view. Then,

documentation activities are carried out during observation and interview activities as a form of visual research data.

The research instruments used observation sheets and interview sheets. The observation sheet contains a grid of activities to be observed in the traditional *Patil* game, while the interview sheet contains a collection of questions to be asked by the interviewer to the informant. Furthermore, the collected data is analyzed using the following steps: (1) Reducing the data from observations and interviews; (2) Presenting data in the form of descriptive text; (3) Drawing conclusions from the results of the analysis; then (4) The data is strengthened with the results of the literature study. Interviews were conducted using Indonesian, and transcription was carried out using an interview code, where the capital letter "P" is used for the researcher and "S" for the subject.

RESULTS AND DISCUSSION

Local wisdom refers to knowledge, values, practices that have developed from generation to generation in a community area (Faiz & Soleh, 2021). Local Wisdom can include traditional values, beliefs, customs, and traditional games that are characteristic of the area (Niman, 2019). The existence of this local wisdom is not only a cultural heritage, but also a foundation for the daily lives of the community (Nurmasyitah et al., 2022). Local wisdom plays an important role in maintaining ecosystem balance, strengthening cultural identity, and promoting socio-economic sustainability (Iswatiningsih, 2019). With increasing globalization, local wisdom is becoming increasingly relevant as a source of inspiration for innovative sustainable solutions such as environmental conservation (Ariza & Tamrin, 2021).

In terms of language, ethnoscience comes from two words, namely ethno and science. Ethno has a cultural meaning and science has a scientific meaning. Therefore, if the word ethno is combined with science, it will describe the science that is typical of a particular ethnic group or community group (Mukti et al., 2022). Ethnoscience was developed to provide local communities with an understanding of how nature works (Putra, 2021). Ethnoscience is also often considered a combination of indigenous knowledge with scientific knowledge (Erman & Suyatno 2022). Thus, it can be concluded that studying ethnoscience is the same as studying science in a historical context. In its implementation, ethnoscience can be studied in schools through science learning, including physics learning.

Local wisdom is a characteristic of a region that includes cultural values and develops in the local scope from generation to generation, and is still maintained by the indigenous people in the area (Dani et al., 2022). One form of local wisdom in Indonesia is traditional games (Sri Wiliat Ningtias, 2021). *Patil Lele* is one of the traditional games that is a cultural/ethnic heritage and must be passed on to the younger generation (Jamalludin, Handayani and Nuraini, 2021). The *Patil Lele* game is a game using simple, easy-to-find, and cheap items, even so, the traditional *Patil Lele* game has many benefits for children (Alfisyah and Rini, 2021). In addition, the *Patil Lele* game contains many values such as togetherness, solidarity, and sportsmanship because it is played in groups, as well as strategies in making plans, from hitting wood to get away to avoiding being caught by opponents (Rohmawati, Ulfa and Fajar, 2019). The *Patil Lele* game has various names in various regions of Indonesia, such as in West Java it is called Patok Lele, in East Java it is called *Patil Lele*, while in Central Java and Yogyakarta it is known as Benthink, and in the Bangka Belitung area it is known as Tak Tek (Burhan and Hidayat, 2023).

The *Patil Lele* game uses 2 pairs of wood, each acting as lever (Nurmasyitah et al, 2022). The long wood is usually called "*induk*" or "*enduk*", while the short wood is usually called "*anak*" (Ningtias, 2021). The *Patil Lele* game does not require special rules, but involves two main roles: the hitter whose job is to hit the wood and the catcher whose job is to catch the wood. There are three ways to play this game. First, the player crosses the short wood on a rock or hole and is ready to throw it with the long wood. Second, the player holds the long wood and the short wood, then hits the short wood as hard as possible with the long wood. Third, the player places the short wood in a slanted position on a stone base, then hits the end of the wood until it is thrown upwards and immediately hits it even harder forward (Amalia, 2021).

The catching team will try to catch the short wooden throw. If they succeed in catching it, the catching team gets a chance to play *Patil Lele*. However, if they fail to catch it, the catching team throws the short wooden near the base stone so that the hitting team does not have enough distance to get a point. The winner of this game is the team that hits the short wooden the furthest.

The *Patil Lele* game includes learning kinematics, especially about parabolic motion. Parabolic motion is a two-dimensional motion that occurs when an object is thrown or shot into the air and follows a parabolic curve (Fauziah & Darvina, 2019). In the *Patil Lele* game, players hit the short wood placed on the wok hard

using a long wood, so that the short wood bounces into the air. The movement of the short wood thrown into the air is a real example of parabolic motion in kinematics (Jamalludin et al., 2021).

In this game, the x -axis represents the distance between the wok and the final position of the short wood that has been hit and not caught by the opponent, while the y -axis describes the vertical motion of the short wood that bounces into the air. When the short wood reaches its maximum height in the air, its vertical velocity is zero, indicating maximum potential motion (Rohmawati et al., 2019).

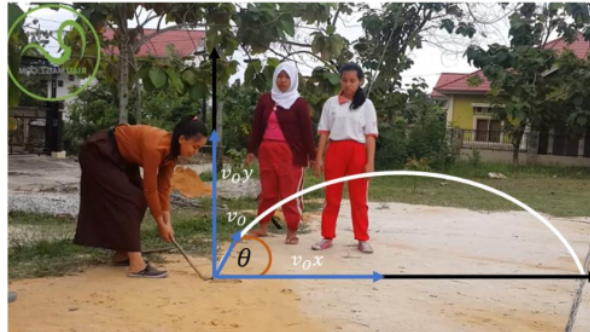


Figure 2. Diagram of the Relationship between Angle, Distance, and Time in the *Patil Lele* Game
(Source: <https://www.youtube.com/watch?v=El4Z-Ad2o8c>)

Figure 1 illustrates the schematic relationship between angle, distance, and time in the game "*Patil Lele*." The analysis of the relationship between distance and time aligns with the theoretical framework that the angle significantly influences the distance achieved, as described by the following equation:

$$x = v_0 \cos \theta t \quad (1)$$

Notation:

- x : the distance between the wok and the small stick that the opponent missed
- v_0 : the initial velocity of the stick when flicked
- $\cos \theta$: the angle formed when the stick is flicked
- t : the time it takes for the stick to reach the ground

In projectile motion, the strike angle significantly affects the horizontal distance (x) achieved. If the stick is struck at a larger angle, the vertical component of the initial velocity increases, causing the stick to reach a higher altitude but with a shorter horizontal distance. Conversely, if the strike angle is smaller, the stick will achieve a greater horizontal distance but at a lower altitude. From Figure 2, it can be understood that the strike angle determines the trajectory of the short stick. Angles more significant than 45 degrees cause the stick to soar higher but cover a shorter distance. The initial velocity (v_0) influences how far and high the stick will fly; a higher velocity results in the stick traveling further and higher. The time (t) relates to the duration the stick remains airborne, which is influenced by the vertical component of the initial velocity and gravitational acceleration.



Figure 3. Illustration of a Player Applying Force
(Source: <https://youtu.be/Go9QcI5Aw3U?si=XQlujejuvKNlm5r5>)

The game of "Patil Lele" not only teaches theoretical concepts of kinematics and projectile motion but also allows players to observe and understand the practical relationships between angle, velocity, distance, and time. This fact makes it an effective tool for teaching fundamental physics concepts. Newton's First Law merely defines the quantity known as mass, but it does not address the cause of an object's motion or rest. Newton's Second Law explains that an object's state of motion can change when a force is applied (Handayani, 2022).

Newton's Second Law in the game of *Patil Lele* occurs when a player holding a long stick applies force to the short stick, causing the short stick to accelerate toward the opponent (Asra et al., 2021). The equation can be expressed as follows:

$$\Sigma F = ma \quad (2)$$

$$a = \frac{\Sigma F}{m} \quad (3)$$

Notation:

F = Force (N)

a = Acceleration ($m \cdot s^{-2}$)

m = Mass (kg)

Alternatively, the equation can be written in differential form as follows:

$$F = m \frac{dv}{dt} \quad (4)$$

$$F = m \frac{d^2 r}{dt^2} \quad (5)$$

In equation (2), if \vec{F} , then 0, as mass cannot be zero. "If there is no force, there is no change in velocity; in other words, the acceleration remains constant." This implies that if the acceleration is zero, Newton's Second Law simplifies to Newton's First Law.

In addition to applying the concepts of projectile motion and Newton's laws, the local wisdom embodied in *Patil Lele* also incorporates the concepts of momentum and impulse. Momentum is a measure of the difficulty of stopping an object. In *Patil Lele*, momentum is generated when the short stick is struck by the long stick, causing the short stick to be thrown. Initially, the long stick possesses more incredible initial momentum (p) because it has a larger mass (m) and velocity (v) compared to the short stick. This momentum is transferred to the short stick, causing it to travel a certain distance. This is consistent with the momentum equation:

$$p = mv \quad (6)$$

Equation (6) indicates that the magnitude of mass and velocity is directly proportional to momentum. In other words, the more significant the mass and velocity of an object, the greater the momentum it generates. Impulse in the game of *Patil Lele* arises when the long stick strikes the short stick, resulting in a collision that changes the momentum. The impulse applied to an object is equal to the change in momentum of that object (Mughny, 2016). When the long stick applies an average impulse force (F) to the short stick over some time (Δt), an impulse (I) occurs. Mathematically, this can be expressed as:

$$I = F\Delta t \quad (7)$$

The primary motion in the game *Patil Lele* involves striking and flipping the short stick with the long stick. The motion of the player flipping the short stick with the long stick is an example of a pushing force. When the player flips the long stick, they push it, allowing it to make contact with the short stick and propel it. The long stick that flips the short stick utilizes the principle of torque. Conceptually, torque (Δt) is the measure of the tendency of a force to rotate an object around a specific axis or pivot point (Arifi et al., 2021). The basic formula for torque is:

$$\tau = F \cdot r \sin \theta \quad (8)$$

(Wulansari and Admoko, 2021)

Notation:

- τ : Torque (N.m)
 r : Length of the lever arm (m)
 F : Magnitude of the applied force (N)
 θ : Angle between the lever arm and the direction of the force

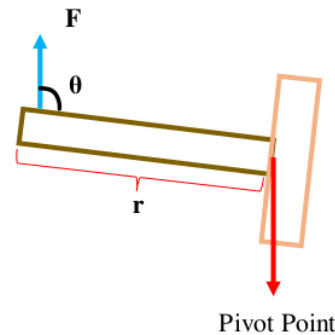


Figure 4. Components of Torque in the Levering Motion of the Short Stick

Figure 4 depicts a child playing *Patil Lele*, using a strategy where a long stick is used to lever the short stick from below. In this situation, torque is calculated before the long stick contacts the short stick. The point where the long stick meets the short stick serves as the axis of rotation. The distance between the hand holding the end of the long stick and the short stick represents the lever arm. The position of the player's hand when holding the long stick forms an angle between the lever arm and the direction of the applied force.

The long stick acts as the lever arm, converting the force exerted by the player's hand into torque when in contact with the short stick. The longer the stick used to strike, the greater the torque produced when hitting the short stick. A more extended lever arm (the distance between the player's hand and the axis) generates greater torque, enabling the short stick to be thrown farther. This observation aligns with the concept of torque, which states that the farther the lever arm is from the axis, the greater the torque; conversely, when the lever arm is closer to the axis, the torque decreases (Sholihah et al., 2023).

When the player uses the long stick to lever the short stick upward, an upward lifting force is applied to the long stick. To lift the short stick with a force w , the player must exert a force F greater than w to elevate the short stick. It is important to note that the position of the applied force, or the position of the player's hand on the long stick, forms an angle θ . The larger the angle θ , the greater the torque produced. Therefore, players aim to position their hands as close to the end of the long stick so that the angle θ approaches 90 degrees (Arifi et al., 2021). Understanding the concept of torque helps players optimize their strikes in the game of *Patil Lele*. By positioning their hands at the end of the long stick, players can generate more torque when levering the short stick, increasing the strength and distance of the stick's throw.

Based on interviews, three techniques for playing *Patil Lele* have been identified: The short stick is placed horizontally over a hole, and the long stick is used to flick the short stick into the air to fall at a certain distance. One end of the short stick is placed inside the hole at an angle and then struck to lift it into the air. While the short stick is airborne, the player strikes it again to send it flying to a certain distance.

The short stick is tossed upward by hand, then struck with the long stick to send it flying to a certain distance. In *Patil Lele*, a team increases its chances of winning by throwing the short stick as far as possible, making it difficult for the opposing team to catch it. Therefore, a team must determine the technique that yields the farthest throw. According to Bagus, a child who frequently plays *Patil Lele*, the first technique produces the farthest throws because the more inclined the short stick is, the farther it travels. Furthermore, the strength of the strike significantly impacts the travelled distance by the short stick.

Table 1. Experimental Results of the *Patil Lele* Game

<i>Patil Lele</i> Technique	Distance Traveled
First Technique	1.78 cm
Second Technique	1.64 cm
Third Technique	1.69 cm

Table 1 shows the experiments conducted by the author to reinforce the previous discussion further. Based on the experimental results, it was found that Technique 1 produced the most significant distance, with a value of 1.78 cm. Thus, it can be concluded that the first technique that is the most effective for achieving the maximum distance in the *Patil Lele* game is the first technique. This technique involves flicking the short stick with the long stick to propel the short stick to a certain distance.

From a physics perspective, the first technique is the most effective for achieving the longest distance. According to the principles of projectile motion, the smaller the angle, the farther the horizontal distance is covered. However, the optimum angle for maximum distance is 45° . The first technique involves a larger angle than the second and third, but only the first allows for the maximum distance. The second and third techniques do not achieve the most extended distances because the short stick is struck at a certain height, resulting in a less steep projectile path and, thus, a shorter distance.

Several factors support the selection of the first technique as the most effective for achieving the longest throw. First, the initial velocity of striking the short stick must be high, as this influences the momentum generated. A higher initial velocity results in the short stick moving more quickly, making it difficult for opponents to position themselves to catch it. Second, the player's hand should be positioned at the end of the long stick. Based on the concept of torque, the farther the lever arm from the axis, the greater the torque generated, thereby increasing the force with which the short stick is thrown and achieving the maximum distance.

CONCLUSION

Based on the analysis, it can be concluded that several physics concepts are applied in the local wisdom of the *Patil Lele* game. These concepts include projectile motion, Newton's laws, momentum and impulse, and torque. The *Patil Lele* game involves three playing techniques. First, the sapling is placed on the hole in a horizontal direction. Then, the parent wood will chip the sapling until it is thrown and falls at a certain distance. Second, the sapling is placed with one end of the sapling in the hole so that when viewed, the wood will appear tilted. Then, the sapling is hit until it floats up. When the sapling floats, the parent wood will hit it again until it is thrown and falls at a certain distance. Third, the sapling is flown upwards using the hand. Then, the parent wood will hit the sapling until it is thrown and falls at a certain distance. Among these, the technique of prying the small stick with the giant stick has been identified as the most effective for achieving the most significant distance, according to the analysis of the underlying physics concepts.

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