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Exploration of Mechanical Energy in the *Pletokan* Traditional Game as Ethnophysics Based Learning Media

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ABSTRACT

The integration of local culture in science learning through an ethnophysics approach can create contextual and meaningful learning experiences. However, studies specifically exploring the concept of mechanical energy in traditional games are still limited. This study aims to explore the concept of mechanical energy in the traditional *Pletokan* game and analyze its potential as an ethnophysics-based physics learning medium. The novelty of this research lies in the exploration of potential energy, kinetic energy, and mechanical energy concepts in the *Pletokan* game from an ethnophysics perspective. This study used a descriptive qualitative approach with an exploratory design. Data were collected through observation, documentation, and literature studies related to the mechanism of the *Pletokan* game and the physical phenomena occurring during gameplay. The results showed that the *Pletokan* game contains concepts of potential energy, kinetic energy, mechanical energy, and energy transformation. These concepts appear during the process of air compression, projectile motion, and the emergence of the characteristic "pletok" sound. The findings indicate that the *Pletokan* game has the potential to be used as an ethnophysics-based physics learning medium that connects physics concepts with local culture in a contextual way. This study implies that traditional games can support innovative physics learning while preserving local cultural values.

INTRODUCTION

Science education needs to be connected with local cultural contexts to make learning more meaningful and relevant to students. The integration of local culture into science education through an ethnoscience approach, including ethnophysics, has been a focus of research in recent years (Zahra et al., 2026). The ethnophysics approach integrates physics concepts with the local culture that has developed within the community, making learning more contextual and relevant to students' lives (Rahman, 2026). Studies indicate that ethoscience based learning can enhance conceptual understanding and student engagement by linking content to the context of daily life (Rahayu et al., 2021; Parmin et al., 2022). Additionally, the use of learning media based on local wisdom, such as traditional games, has proven effective in creating contextual and meaningful learning (Shofyana et al., 2024). Culturally-based learning can also help students understand

abstract concepts in physics through real-world experiences they encounter in their surroundings (Nazara et al., 2025). Other studies confirm that integrating culture into physics education can enhance students' science literacy, critical thinking skills, creativity, and motivation to learn (Khoiri et al., 2020; Nasution et al., 2023). Thus, ethnophysics not only plays a role in improving the quality of education but also serves as a means of preserving local culture amidst technological advancements and modernization.

One form of local culture that can be utilized in physics education is traditional games. Traditional games not only hold cultural and social value but also incorporate various scientific concepts that can be explained through a physics-based approach (Pratiwi et al., 2025). Many traditional games utilize principles of force, motion, pressure, work, and energy in their gameplay mechanisms. On the other hand, the concept of mechanical energy as the combination of potential energy and kinetic energy is a fundamental concept in physics that is frequently explored in experiment based and contextual learning (Yusuf et al., 2021; Mulyaningsih et al., 2023). Understanding the concept of mechanical energy is crucial because it relates to various phenomena in daily life. However, the teaching of mechanical energy in schools is often still theoretical and centered on mathematical problem solving, causing students to struggle to connect the concept with real-world phenomena in their surroundings.

Although research on ethnophysics and culture based learning has grown considerably, several research gaps remain. Previous studies have primarily examined basic physics concepts, such as force, motion, and pressure, through various traditional games, including slingshots, *kapal otok-otok*, and jump rope (Aryani et al., 2025; Pratiwi et al., 2025; Zahra et al., 2026). Based on the literature reviewed by the authors, no previous study has specifically explored the concept of mechanical energy in the traditional Pletokan game from an ethnophysics perspective. Existing studies also tend to emphasize classroom implementation rather than the conceptual exploration of the physical phenomena contained within the game. However, in depth conceptual exploration is crucial as a foundation for developing ethnophysics based learning media. The traditional *Pletokan* game holds significant potential for study because its mechanics involve air pressure, projectile motion, sound, and energy transformations directly related to the concept of mechanical energy. Therefore, this study offers a novel approach by specifically exploring the concept of mechanical energy in the traditional *Pletokan* game from an ethnophysics perspective, which has not been extensively examined in previous research.

However, in depth conceptual exploration is crucial because it provides a scientific foundation for developing contextual physics learning, including ethnophysics based learning materials, contextual learning problems, and learning activities that relate physics concepts to students' daily experiences. Based on the reviewed literature, previous studies have mainly explored physics concepts in various traditional games or investigated the implementation of ethnophysics based learning in classroom settings (Aryani et al., 2025; Pratiwi et al., 2025; Zahra et al., 2026). However, no study has specifically provided a comprehensive conceptual analysis of mechanical energy including potential energy, kinetic energy, energy transformation, and mechanical energy in the traditional Pletokan game from an ethnophysics perspective. Therefore, the novelty of this study lies in filling this research gap by providing a comprehensive conceptual exploration of mechanical energy in the Pletokan game, which serves as a scientific foundation for developing contextual ethnophysics based physics learning. Based on the above, this study addresses the following research questions:

RQ1: How are the concepts of potential energy, kinetic energy, and mechanical energy represented in the traditional Pletokan game?

RQ2: How can the traditional Pletokan game be utilized as a contextual resource for ethnophysics-based physics learning?

To answer these research questions, this study explores the concept of mechanical energy in the traditional Pletokan game and analyzes its potential as a contextual resource for ethnophysics-based physics learning.

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RESEARCH METHOD

This study employs a descriptive qualitative approach with an exploratory design to examine the concept of mechanical energy in the traditional game of *Pletokan* as an ethnophysics-based learning medium. The research procedure is illustrated in **Figure 1** below.

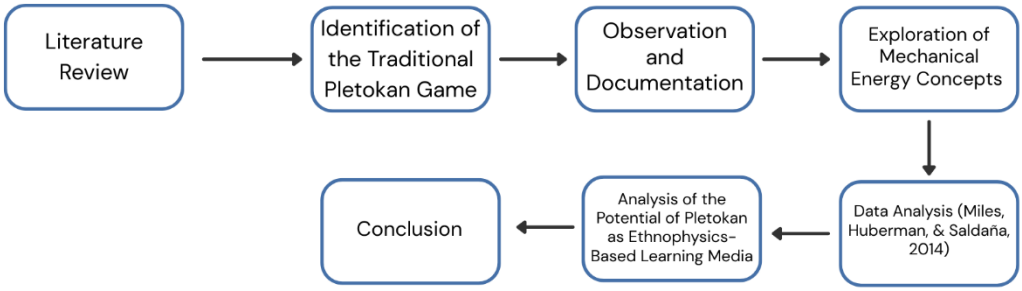

Figure 1 Research Flowchart.

The data sources in this study consist of primary and secondary data. Primary data were obtained from direct observations of the traditional *Pletokan* game, including the shape of the equipment, the materials used, how to play, the shooting process, and the physical phenomena that occur during the game. Secondary data were obtained from books, peer reviewed journals, conference proceedings, and other scientific publications related to mechanical energy, ethnophysics, traditional games, and physics learning (Aryani et al., 2025). The literature search was conducted through book, and Google Schoolar using the keywords "ethnophysics," "ethnoscience," "traditional games," "*Pletokan*," "mechanical energy," "physics learning," and "local wisdom." The selected references were screened based on their relevance to the objectives of this study**.** The research procedure began with identifying the *Pletokan* device and its operating mechanism, followed by field observations to identify the emergence of elastic potential energy, kinetic energy, and energy transformation during the firing process. The observed findings were then visualized through illustrations of the *Pletokan* components and the mechanical energy concepts identified in the game. An ethnophysics approach was applied to relate the identified physics concepts to local cultural practices, thereby providing a contextual understanding of physics learning (Fakhruddin et al., 2025).

Data collection techniques were conducted through observation, documentation, and literature review (Sugiyono, 2022). The literature review was conducted systematically by identifying, selecting, and reviewing relevant publications using the predetermined keywords. Observation data, documentation, and literature findings were subsequently organized according to the identified mechanical energy concepts before analysis**.** The collected data were analyzed using the interactive qualitative analysis model proposed by Miles, Huberman, and Saldaña (2014), which consists of data condensation, data display, and conclusion drawing/verification. During the analysis, the observation results, documentation, and literature findings were coded and grouped into themes representing elastic potential energy, kinetic energy, energy transformation, and mechanical energy. These themes were then interpreted using an ethnophysics perspective to explain the relationship between the operating principles of the traditional Pletokan game and its potential as an ethnophysics based learning medium. The findings were subsequently used to explain how traditional games can function as contextual learning media that facilitate students' understanding of physics concepts while contributing to the preservation of local culture (Damayanti & Mundilarto, 2020).

RESULTS AND DISCUSSION

This study is an exploratory study using a descriptive qualitative approach aimed at examining the concept of mechanical energy in the traditional game of *Pletokan* as an ethnophysics-based learning medium. The study was conducted through direct observation of the *Pletokan* game to identify various physics concepts that emerge during gameplay. The focus

of the study is not only on the use of *Pletokan* as a traditional game but also on an in-depth exploration of the concepts of potential energy, kinetic energy, and mechanical energy inherent in the game's mechanics. Additionally, this study utilizes literature reviews, documentation, and analysis of physical phenomena related to the working principles of *Pletokan* to strengthen the research findings.

An ethnophysics approach is employed in this study to connect physics concepts with local culture, thereby making learning more contextual and meaningful (Fakhruddin et al., 2025). The traditional *Pletokan* game was selected because it has a close connection to the concepts of work, force, air pressure, motion, and energy transformation, which students can observe directly (Safitri et al., 2023). The integration of traditional games into physics learning is also expected to create a more engaging, contextual, and less monotonous learning environment (Damayanti & Mundilarto, 2020; Wati et al., 2022). Until now, physics instruction has often focused solely on mathematical problem-solving and the use of equations, causing students to struggle in understanding the connection between concepts and real-world phenomena in their surroundings (Jannati, 2026).

The literature review revealed that previous studies have identified traditional games as potential resources for ethnophysics based physics learning because they contain various physics concepts closely related to everyday life. Several studies reported that traditional games represent concepts of force, motion, pressure, work, and energy (Aryani et al., 2025; Wati et al., 2022). Abdulfattah and Putranta (2020) explained that the traditional Pletokan game involves air pressure and projectile motion, while Safitri et al. (2023) stated that traditional games can be utilized as contextual learning media in physics education. These findings indicate that traditional games have strong potential to support contextual physics learning and provide a theoretical basis for the present study.

Based on the results of observations, documentation, and literature reviews conducted, it was found that the traditional *Pletokan* game incorporates various physics concepts related to mechanical energy. These concepts include potential energy resulting from air pressure inside the bamboo, kinetic energy when the projectile moves, and the conversion of mechanical energy into sound energy when the characteristic "*pletok*" sound is heard. Furthermore, the analysis results also indicate that the *Pletokan* game has the potential to serve as a culture-based physics learning medium that can help students understand energy concepts in a contextual manner. The research findings and discussion are systematically presented in the following section.

Overview of the Traditional Game of *Pletokan*

Below is an illustration of the traditional game of *Pletokan*, which consists of a bamboo frame and paper projectiles, as shown in **Figure 2** below.

Figure 2 *Pletokan* bamboo and paper projectiles

The *Pletokan* is a traditional game made from bamboo (Abdulfattah & Putranta, 2020). The bamboo used is typically mature bamboo, as it is more durable and less prone to breaking during play compared to young bamboo (Suninastuti, 2020). This bamboo generally has a diameter of about 0.5 to 1 cm and is cut to a length of approximately 25 cm to serve as the barrel. Inside the

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barrel is a propeller shaft that is smaller in diameter than the barrel so that it can move inside it. The smaller size of the pusher rod ensures that the projectile is propelled effectively during play. Additionally, at the connecting end, there is a grip sleeve that makes it easier for the player to hold and operate the *Pletokan*. The main components of the *Pletokan*, as described above, are shown in **Figure 3.**

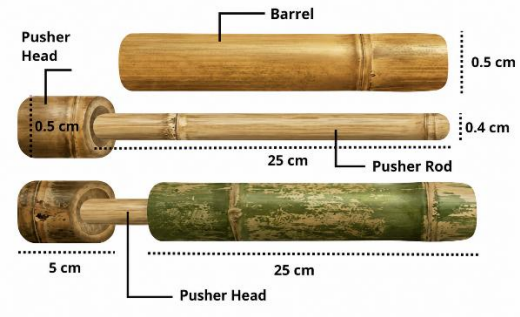


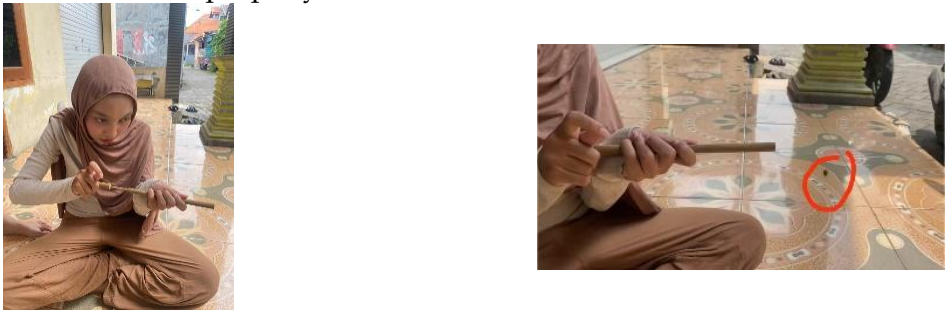
Figure 3. Design of the components of the traditional *Pletokan* game.

The following are the steps for making a *Pletokan* as applied in this study:

1. An old bamboo stalk approximately 30 cm long and 0.5–1 cm in diameter is cut into two pieces. The first section is used as a 25 cm barrel, while the second section is used as a 5 cm handle, as shown in **Figure 4.**
2. After cutting, the bamboo surface is smoothed using sandpaper. This smoothing process aims to make the game more comfortable for players to hold and to reduce the risk of hand injury when using the *Pletokan*.
3. The next step is to make the pusher rod used to propel the projectile inside the barrel. The pusher rod is made to a size that allows it to move smoothly inside the bamboo.
4. The next step is to ensure the connection between the pusher rod and the pusher base does not come loose easily. The pusher base is then glued in place to make it stronger and more stable during play.
5. The final step involves preparing newspaper or a similar material to be turned into paper pulp for use as projectiles. Choosing paper with a soft texture is intended to prevent pain or injury when it strikes the player's body.

How to Play *Pletokan*

Once the crafting process is complete, the *Pletokan* is ready to be used as a toy. Playing this game is quite simple, as shown in **Figure 4.** Players simply need to follow a few steps to ensure the projectiles are fired properly.



(a) (b)

Figure 4. The *Pletokan* is pulled back (a) and then pushed forward (b) so that the projectile is released

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The first step the player takes is to prepare the *Pletokan* along with the projectiles, which are made of paper pulp shaped into small balls. Once the projectiles are ready, they are inserted into both ends of the bamboo barrel. When the projectiles are in position, the player inserts the ramrod and pushes it into the barrel until the projectiles are ejected. As shown in Figure 3, the *Pletokan* mechanism begins when the player rapidly moves the ramrod inward toward the bamboo barrel. This motion compresses the first projectile, reducing its volume due to the compression of air inside the barrel. Subsequently, the first projectile pushes the second projectile located at the other end of the barrel until the second projectile is ejected from the *Pletokan*. When the second projectile exits, the volume of the first projectile returns to its original state as the air pressure inside the casing reverts to its initial condition. The ejected second projectile follows a specific trajectory resembling a parabolic motion. The process of the projectile's ejection also produces the characteristic "*pletok*" sound, which is the defining feature of this traditional game.

Results of the Exploration of Mechanical Energy Concepts in Physics

The research findings indicate that the traditional game of *Pletokan* has a strong connection to the concept of mechanical energy in physics. Based on direct observations, the mechanism of the *Pletokan* utilizes the energy transformation that occurs when the projectile is propelled using a bamboo rod. When the propelling rod is compressed, the air inside the bamboo is pressurized, thereby storing potential energy. When the pressure is released, this energy is converted into kinetic energy, causing the projectile to shoot out and produce the characteristic "pletok" sound. Furthermore, the observations indicate that the length of the bamboo, the magnitude of the pushing force, and the size of the projectile influence the velocity and range of the shot. These findings demonstrate a relationship between force, work, and mechanical energy in the traditional *Pletokan* game. The physics concepts identified during the study are presented in **Table 1.**

Table 1. Exploring the Concept of Mechanical Energy in the Traditional Game of *Pletokan*

No	The Phenomenon at *Pletokan*	Physics Concepts	Explanation
1	The push rod is pressed	Potential Energy	When the plunger is pushed into the bamboo, the air inside the tube is compressed, thereby storing potential energy. Potential energy depends on an object's position relative to the Earth's surface (Abdullah, 2016). The greater the distance of the projectile from the Earth's surface, the greater its potential energy. The amount of potential energy in the projectile can be determined using the following equation: $Ep = mgh$ …(1)
2	The bullet flew out	Kinetic Energy	Once the air pressure inside the bamboo increases, the projectile is propelled out at a certain speed. The projectile's motion demonstrates the presence of kinetic energy because it has mass and is moving. Kinetic energy is the energy possessed by an object due to its motion or speed. Every moving object possesses kinetic energy, and the magnitude of this energy is determined by the object's mass and velocity. The greater the mass and the faster the object moves, the greater its kinetic energy (Abdullah, 2016). This can be expressed as follows: $Ek = ½mv^2$ …(2)
3	The bullet is moving through the air	Mechanical Energy	As a bullet travels through the air, a combination of potential energy and kinetic energy occurs, known as mechanical energy. Kinetic energy arises because the bullet is moving, while potential energy is determined by the bullet's position or height relative to the Earth's surface. As the bullet moves along a parabolic trajectory, these two

No	The Phenomenon at *Pletokan*	Physics Concepts	Explanation
			forms of energy transform into one another, yet the total mechanical energy remains constant. This aligns with the law of conservation of mechanical energy, which states that the sum of kinetic and potential energy in a system will always remain constant if no external forces are acting upon it (Abdullah, 2016). It can be expressed as follows: $Em = Ep + Ek$ …(3)
4	A *"pletok"* sound is heard	Energy Transition	The *"pletok"* sound occurs due to the rapid release of air pressure as the projectile exits the bamboo tube. During this process, energy is converted from the potential energy of air pressure into sound energy. The greater the air pressure inside the bamboo, the louder the sound produced when the projectile is fired (Halliday, Resnick, & Walker, 2014).
5	The projectile moves out of the *Pletokan*	Law of Mechanical Energy Conservation	Under ideal conditions without friction and air resistance, the traditional *Pletokan* game can be explained using the law of mechanical energy conservation, where the total amount of potential energy and kinetic energy remains constant. The potential energy stored due to compressed air before the projectile moves is converted into kinetic energy when the projectile is launched from the *Pletokan*. However, in real conditions, part of the energy is transformed into heat and the "pletok" sound due to friction between the projectile and the bamboo wall as well as air resistance. The equation of the law of mechanical energy conservation can be written as follows: $Ep + Ek = constant$

1. Gravitational Potential Energy

In the traditional game of *Pletokan*, the concept of gravitational potential energy is used, as shown in **Figure 5 below.**

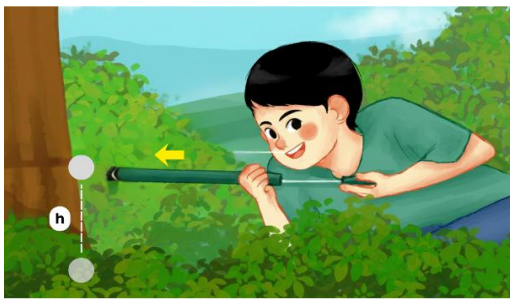

Figure 5 Illustration of the Physics Concept of Potential Energy in the Game "*Pletokan*"

In Figure 5, when a player lifts the shuttlecock before hitting it, the concept of gravitational potential energy comes into play. Potential energy is the energy possessed by an object due to its position or height relative to the Earth's surface, particularly in the case of objects with mass (Abdullah, 2016). The higher the position of the shuttlecock when lifted by the player, the greater the gravitational potential energy possessed by the object. Mathematically, the gravitational potential energy of the *Pletokan* can be expressed by the equation:

$$E_p = m\vec{g}h \quad \text{…(1)}$$

2. Kinetic Energy

In the traditional game of *Pletokan*, the concept of kinetic energy is applied, as shown in **Figure 6** below.

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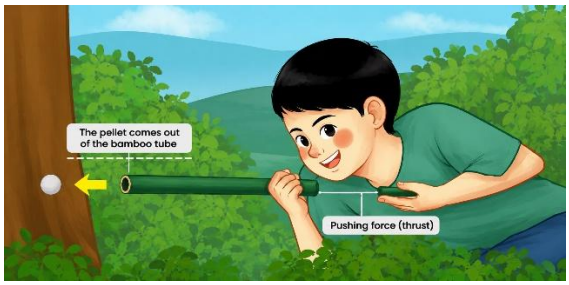

Figure 6. Illustration of the Physical Concept of Kinetic Energy in the *Pletokan* Game

In **Figure 6,** kinetic energy is the energy possessed by an object as a result of its motion (Serway & Jewett, 2020). In the traditional game of *Pletokan*, kinetic energy arises when the projectile and the propelling bamboo rod move as a result of the air pressure generated inside the bamboo barrel. This kinetic energy is the result of the conversion of the potential energy of the air pressure stored during the air compression process. The magnitude of an object's kinetic energy can be mathematically expressed as:

$$Ek = \frac{1}{2}m\vec{v}^2 \quad \ldots(2)$$

In the *Pletokan* game, kinetic energy is primarily possessed by the projectile as it shoots out of the barrel. The greater the air pressure generated by the thrust of the bamboo rod, the greater the projectile's velocity, and thus the greater its kinetic energy. In addition to the projectile, the bamboo rod also possesses kinetic energy as it is thrust into the barrel. The bullet's kinetic energy decreases due to air resistance and environmental drag. Some of the kinetic energy is also converted into sound energy, characterized by the distinctive "pletok" sound, as well as thermal energy resulting from friction between the bullet and the bamboo barrel walls (Patil & Mandale, 2021).

3. Mechanical Energy

In the traditional game of *Pletokan*, the concept of mechanical energy is applied, as shown in **Figure 7** below.

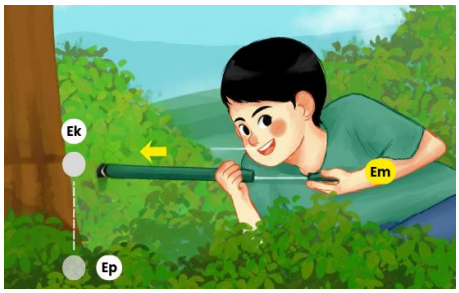

Figure 7 Illustration of the Physical Concept of Mechanical Energy in the *Pletokan* Game

In Figure 7, when the player applies a pushing force to the bamboo rod, the chemical energy of the muscles is converted into mechanical energy. This mechanical energy manifests as the movement of the bamboo rod, which travels a certain distance into the barrel. Mechanical energy is a combination from kinetic energy and potential energy. In the motion of a rod, mechanical energy is dominated by kinetic energy. Here is the equation for mechanical energy:

$$Em = Ek + Ep \quad \ldots(3)$$

4. The Law of Conservation of Mechanical Energy

In the traditional game of *Pletokan*, the concept of the law of conservation of mechanical energy is applied, as shown in **Figure 8 below.**

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Figure 8 Illustration of the Physical Concept of the Law of Conservation of Mechanical Energy in the *Pletokan* Game

Under ideal conditions with no friction or air resistance the *Pletokan* game can be explained using the law of conservation of mechanical energy, in which the sum of potential energy and kinetic energy remains constant. The potential energy stored before the projectile moves will be completely converted into kinetic energy when the projectile leaves the *Pletokan*. However, in real world conditions, some of the energy is converted into heat and the "*pletok*" sound due to friction between the projectile and the bamboo walls as well as air resistance.

Based on **Table 1**, it can be seen that the traditional game of *Pletokan* incorporates various physics concepts related to mechanical energy (Safitri et al., 2023). The energy generation process begins when the push rod is pressed, causing the air inside the bamboo to be compressed and store potential energy (Fania, 2025). This energy is then converted into kinetic energy as the projectile moves out of the bamboo. As the projectile moves, energy changes and transfers occur, demonstrating the concept of mechanical energy. Additionally, the "*pletok*" sound produced represents the conversion of mechanical energy into sound energy due to the sudden release of air pressure (Retno, 2021). Observations also indicate that the greater the force applied, the greater the energy generated, resulting in a longer shooting distance. These findings suggest that the *Pletokan* game can be used to explain the concepts of potential energy, kinetic energy, and the law of conservation of energy in a contextual manner within physics education.

The results of this study indicate that the traditional *Pletokan* game can be utilized as an ethnophysics based learning medium because it effectively integrates physics concepts with local culture. The research findings show that students can learn mechanical energy concepts contextually through direct experience in playing *Pletokan*. The use of locally based cultural media makes learning more engaging and easier to understand because physics concepts are not only explained theoretically but also observed through real world phenomena in the surrounding environment. These findings align with the research by Aryani et al. (2025), which states that traditional games can be used as a safe and enjoyable medium for physics learning. Additionally, Fakhruddin et al. (2025) also explain that the ethnophysics approach can enhance the connection between scientific concepts and the lives of local communities. This study reinforces the view of Damayanti and Mundilarto (2020) that learning based on local wisdom can improve students' conceptual understanding and engagement in the learning process. Thus, the traditional game of *Pletokan* not only holds cultural value but also has the potential to serve as an innovative physics learning medium that is contextual, interactive, and meaningful in helping students understand the concept of mechanical energy.

CONCLUSION

Based on the research findings, the traditional game of *Pletokan* incorporates the concept of mechanical energy, which consists of potential energy and kinetic energy that are interrelated throughout the course of the game. Potential energy arises when air inside the bamboo is compressed, then transforms into kinetic energy as the projectile moves out of the barrel, producing motion and the "*pletok*" sound. The research findings also indicate that the traditional *Pletokan* game has the potential to be used as an ethnophysics based physics learning medium because it effectively connects physics concepts with local culture in a contextual manner that is

easily understood by students. Thus, this study provides a conceptual foundation for the development of innovative physics learning media that are relevant to daily life and support the integration of local wisdom into education. This study has limitations because it focuses only on exploring the concept of mechanical energy in the *Pletokan* game and has not tested the effectiveness of its use in the classroom learning process. Additionally, this study examines only one type of traditional game, so the physics concepts identified remain limited. Future research can be developed by testing the influence of *Pletokan* based learning media on students' learning outcomes and thinking skills. Research can also be expanded to include other traditional games so that ethnophysics studies become broader and more diverse.

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AUTHOR CONTRIBUTIONS

Icha Fauzyah Rossiana: Conceptualization, Methodology, Investigation, Formal Analysis, Visualization, and Writing Original Draft. **Habibi**: Methodology, Validation, Formal Analysis, Resources, and Writing Review & Editing. **Galuh Aryseno**: Supervision, Project Administration, Validation, and Writing Review & Editing. All authors have read and approved the published version of the manuscript.

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