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# An Ethnophysics Exploration of Traditional Marble Games: Analysis of Momentum and Impulse Concepts

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**ABSTRACT**

Physics learning is often perceived as abstract and less relevant to students' daily lives, resulting in low motivation and conceptual understanding. One approach that can overcome this problem is ethnophysics, which integrates physics concepts with local culture and traditional activities. This study aims to explore the concept of momentum in traditional marble games through an ethnophysics approach. This research used a qualitative descriptive method with an exploratory design. Data were collected through observation, documentation, and literature studies related to ethnophysics, traditional marble games, and momentum concepts. The novelty of this study lies in the specific analysis of momentum concepts in traditional marble games, which has rarely been explored in previous ethnophysics studies. The results showed that momentum and Impulse concepts appear during the movement and collision of marbles in the game. The magnitude of momentum is influenced by the mass and velocity of the marbles, where larger marbles produce greater momentum and faster-moving marbles generate stronger collisions. These findings indicate that traditional marble games can be used as contextual and meaningful physics learning resources on momentum concepts. This study contributes to the development of ethnophysics-based learning through the integration of local culture into physics education.

## INTRODUCTION

Physics education is still often perceived as abstract and irrelevant to daily life, leading to low student motivation and poor conceptual understanding (Sasmi et al., 2025). Therefore, a teaching approach is needed that can connect physics concepts to real-world contexts in students' environments. Contextual learning approaches are considered effective because they enable students to relate abstract scientific concepts to phenomena that are familiar in their daily lives, thereby promoting more meaningful learning experiences (Fathoni, 2024; Rini et al., 2023). One emerging approach is ethnophysics, which integrates physics concepts with the culture and local wisdom of the community (Astuti et al., 2025). This approach is considered capable of creating more contextual learning because physics concepts are studied through cultural activities that are closely related to students' lives.

Various studies indicate that ethnophysics has the potential to improve the quality of physics education. Rizki et al. (2022) state that ethnophysics-based learning can enhance students' conceptual understanding because it is linked to local culture that is familiar in everyday life. Ningrum et al. (2025) explain that traditional games contain various physics concepts such as force, energy, and momentum that can be utilized as contextual learning resources. Additionally, Sholahuddin & Admoko. (2021) demonstrate that ethnophysics-based learning can enhance students' critical thinking skills. Other studies also reveal that integrating local culture into science learning can increase student engagement and learning outcomes (Rini et al., 2023). According to a study by Fathoni. (2024), learning based on local culture can increase interest in learning because students find it easier to understand material related to their daily experiences. Furthermore, local cultural activities can support students' observational and scientific reasoning skills in science education.

In addition to enhancing conceptual understanding, the ethnophysics approach also plays a role in preserving local culture amid the development of modern technology. Traditional games that are increasingly rarely played by the younger generation can be utilized as a learning medium so that their existence remains recognized in community life. According to Mulyani et al. (2024), integrating local culture into learning can raise students' awareness of the importance of preserving regional culture. Culture-based learning can strengthen cultural identity while creating a more meaningful learning experience (Atmaja, 2023). Thus, ethnophysics not only contributes to science education but also supports the preservation of local culture through educational activities.

One form of local culture that has the potential to be utilized in physics education is the traditional game of marbles. This game involves the motion and collisions of marbles, which are related to the concepts of momentum and impulse. The traditional marble game was selected because it naturally demonstrates the concepts of momentum, impulse, and collisions through direct interactions among marbles. Unlike many other traditional games, marbles allow observable variations in mass, velocity, and collision outcomes, making them particularly suitable for ethnophysics studies. In addition, the game remains familiar to many Indonesian students, allowing physics concepts to be contextualized through cultural experiences that are closely connected to their daily lives. The phenomena of momentum transfer and changes in motion can be observed as the marbles move and collide during the game. Momentum and impulse are important concepts in the study of motion and collisions that can be observed through the interaction between objects (Halliday, 2014). Thus, the traditional game of marbles has the potential to be used as a contextual resource for learning physics through an ethnophysics approach.

The traditional game of marbles can also provide a more active learning experience because students can directly observe the processes of motion and collision that occur during the game (Pulungan et al., 2023). This activity allows students to connect real-world phenomena with the physics concepts they learn in class. According to Fauzi et al. (2023), contextual activity-based learning can increase students' participation and scientific thinking skills compared to learning that is solely theory-centered. Additionally, the use of traditional games as a learning medium can create a more engaging and enjoyable learning atmosphere, making it easier for students to understand abstract concepts in physics (Aryani et al., 2025).

Although ethnophysics has been widely explored, previous studies have mainly focused on identifying general physics concepts in traditional games rather than providing detailed

analyses of specific concepts. For example, Nuryadin et al. (2023) investigated the concept of force in the traditional *Bambu Gila* game and demonstrated the existence of physics principles embedded in local culture; however, the study did not examine the concepts of momentum and impulse. Likewise, Ningrum et al. (2025) conducted a literature review demonstrating that traditional games contain various physics concepts, including force, energy, momentum, and impulse. However, the study synthesized previous findings without examining how these concepts are manifested through direct observation of gameplay. Furthermore, Sesrita et al. (2025) explored physics concepts in traditional marble games and successfully identified several relevant concepts. However, the study focused primarily on concept identification and did not explain how momentum and impulse emerge through actual collision events observed during gameplay. These findings indicate that a detailed ethnophysics analysis of momentum and impulse in traditional marble games remains limited.

The novelty of this study lies in providing a comprehensive ethnophysics analysis of momentum and impulse through direct observation of traditional marble gameplay. Unlike previous studies, which primarily focused on identifying the existence of physics concepts, this study explains how variations in marble mass, velocity, and collision interactions illustrate the principles of momentum and impulse and discusses their relevance as contextual learning resources in physics education. Based on these research gaps, this study aims to (1) analyze the manifestations of momentum and impulse in traditional marble games through direct observation and (2) explain their relevance to physics education through an ethnophysics perspective.

## RESEARCH METHOD

This study employed a qualitative descriptive approach with an exploratory design. Primary data were collected through direct observation of traditional marble games and photographic documentation of the gameplay activities (Sugiyono, 2022). Secondary data consisted of journal articles, books, and other scholarly publications related to ethnophysics, traditional games, momentum, and impulse. These scholarly sources were used to provide theoretical foundations and empirical evidence for interpreting the observed physical phenomena, thereby improving the credibility and trustworthiness of the findings (Creswell & Creswell, 2018). During the observation stage, the researchers identified physical phenomena occurring in the motion and collision of marbles, including changes in velocity, direction of motion, momentum transfer, impulse, and types of collisions (Yin, 2018). These phenomena were analyzed and compared with theoretical concepts presented in the literature to determine the relationship between traditional marble games and the concepts of momentum and impulse (Cahyani et al., 2024).

The collected data were then analyzed using the Miles and Huberman model, which consists of four stages: (1) data collection, by gathering observational data and relevant scientific literature; (2) data reduction, by selecting and simplifying data related to momentum and impulse phenomena; (3) data presentation, by organizing the findings into descriptive narratives and tables to facilitate interpretation; and (4) conclusion drawing, by identifying the relationship between the traditional marble game and the concepts of momentum and impulse based on the results of the analysis (Gilal et al., 2022).

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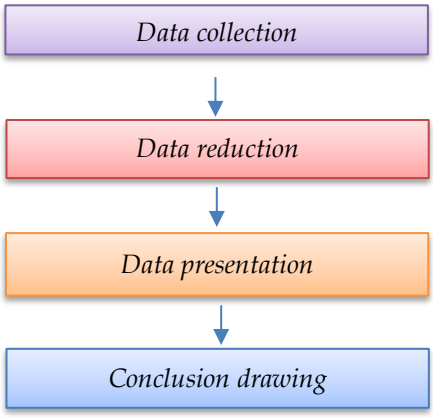


**Figure 1.** Stages of Qualitative Descriptive Data Analysis

During the data collection stage, observations and documentation were carried out while the traditional marble game was being played. Data reduction involved selecting only observations relevant to the concepts of momentum and impulse. Data display was conducted by organizing the findings into descriptive explanations, figures, and tables to facilitate interpretation. Finally, conclusions were drawn by comparing observational findings with established theories of momentum and impulse and previous ethnophysics studies.

## RESULTS AND DISCUSSION

### The Traditional Game of Marbles in Ethnophysics Studies

**Figure 2.** playing marbles

Traditional games are part of local culture that continue to thrive in society and hold educational value in everyday life. Figure 2 illustrates the traditional marble game used in this study. The image demonstrates the initial position of the marbles before interaction occurs. This gameplay situation provides opportunities to observe the motion of marbles, the occurrence of collisions, and the transfer of momentum, all of which are closely related to the concepts of momentum and impulse in physics. One traditional game that is still well-known and played by children is the game of marbles. In addition to serving as entertainment, traditional games also contain various scientific concepts that can be explored in physics education through an ethnophysics approach. The marbles game is typically played by flicking a marble with a finger to hit a target marble located within a circle or specific area. A player who successfully hits or knocks an opponent's marble out of the playing area earns points or wins the game.

Ethnophysics is a learning approach that integrates physics concepts with local culture and community activities, making learning more contextual and meaningful (Astuti et al., 2025). This approach enables students to understand physics concepts through phenomena closely related to daily life. In the traditional game of marbles, there are activities involving motion, force, velocity, and collisions that relate to physics concepts, so the game has the potential to be utilized as a source of physics learning based on local culture.

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The local cultures that have developed in each region are generally familiar to students from an early age (Isnaniah & Masniah, 2022). One form of such local culture is traditional regional games. The traditional game of marbles is closely tied to students' daily lives, so it can help them connect physics concepts with real-world experiences during play. In addition to helping students understand physics concepts more concretely, the integration of traditional games can demonstrate the presence of physics phenomena related to the concept of momentum in traditional game activities (Afkarina, 2021).

**Analysis of the Physics Concepts of Momentum and Impulse in the Traditional Marble Game**

Based on direct observations and a literature review, the traditional marble game demonstrates the presence of the concepts of momentum and impulse that appear during the interactions and collisions throughout the game. These physical phenomena occur naturally when a moving marble interacts with another marble, resulting in changes in velocity and momentum transfer that can be directly observed. According to Halliday et al. (2014), momentum is determined by the product of an object's mass and velocity, while impulse represents the change in momentum caused by a force acting over a short period of time. Therefore, the interactions occurring during marble games provide concrete examples of these physics concepts. This finding is consistent with Rizki et al. (2022), who reported that traditional games provide authentic contexts for connecting abstract physics concepts with students' everyday experiences in Table 1.

**Table 1.** Physics Concepts of Momentum and Impulse

| Physics Concepts | Traditional Marble Games |
|---|---|
| Momentum | Momentum is a physical quantity possessed by a moving object and is influenced by the object's mass and velocity. In traditional marble games, momentum is evident when a marble moves toward a target after being propelled by a player. This observation is consistent with Halliday et al. (2014), who explain that an increase in mass or velocity results in greater momentum. Likewise, Rizki et al. (2022) reported that traditional games provide authentic situations for demonstrating momentum through observable object motion. |
| Impulse | Impulse is the product of force and the time interval during which the force acts on an object. In the traditional game of marbles, impulse occurs when a player flicked a marble, causing a change in the marble's motion. This finding aligns with Halliday et al. (2014), who state that impulse is directly related to changes in momentum. In addition, Ningrum et al. (2025) identified collisions and impulsive forces in traditional games as contextual examples for physics learning. |

**The Concept of Momentum in Physics**

The results of the observation show that the traditional game of marbles involves the physics concept of momentum, which comes into play during the course of the game. In physics, the concept of momentum states that every moving object possesses momentum, which is determined by the object's mass and velocity. Momentum is a vector quantity that has both magnitude and direction, with its direction aligned with the direction of the object's motion.

$$\vec{p} = m\,\vec{v} \quad (1)$$

This equation shows that momentum is directly proportional to an object's mass and velocity. The concept of momentum can be observed in the traditional game of marbles. In this game, the concept is evident when a marble moving faster produces a stronger collision than one moving slowly. This finding indicates that the concept of momentum can be directly observed through the traditional game of marbles. The results of this study align with research Astuti et al.

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(2021) stating that traditional games contain physics concepts relevant to culture-based learning. This is consistent with the theory of momentum, which states that momentum is the product of an object's mass and velocity (Halliday et al., 2014).

**Table 2.** Explanation of the Concept of Momentum in the Traditional Game of Marbles

| No | Activities in the Marble Game | The Concept of Momentum | Explanation |
|---|---|---|---|
| **1** | The player flips the marble with a finger | Momentum | A marble moves after being acted upon by a force, so it has momentum based on its mass and speed. |
| **2** | The marble moves quickly toward the target | The Effect of Speed on Momentum | A marble moving faster has greater momentum. |
| **3** | The marble hits the target marble | Transfer of Momentum | The momentum of the moving marble is transferred to the target marble. |
| **4** | The target marble moves after the collision | The Effect of Momentum on Motion | The target marble travels farther when struck by a marble with greater momentum. |

Based on the observations, momentum in the traditional game of marbles is evident in the motion of the marbles after they are given an initial push by the player. The greater the mass and velocity of the marbles, the greater the momentum generated, resulting in stronger motion. This observation agrees with the theory of momentum, which states that momentum is the product of an object's mass and velocity (Halliday et al., 2014).

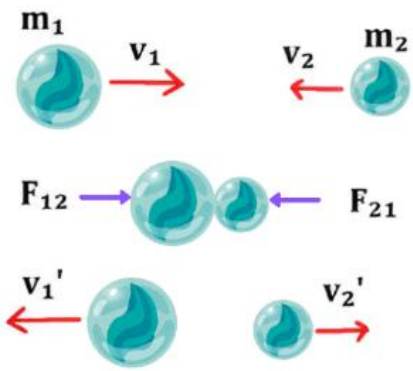


**Figure 3.** Two marbles before and after a collision

Figure 3 shows the collision between two marbles moving in opposite directions. The interaction illustrates momentum transfer and changes in velocity after the collision. This phenomenon reflects Newton's Third Law as well as the conservation of momentum during collisions. Marble 1 and marble 2, which have the same mass, move on a flat surface at speeds $v_1$ and $v_2$ respectively. Marble 1 moves to the right, while marble 2 moves to the left, so they move in opposite directions and collide. After the collision, the direction of motion of both marbles changes: Marble 1 moves to the left and Marble 2 moves to the right with new velocities $v_1'$ and $v_2'$ respectively. The interaction of forces during the collision demonstrates the existence of a pair of action and reaction forces in accordance with Newton's Third Law. Therefore, the relationship between the forces on the two marbles can be expressed as follows:

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$$\begin{aligned} \text{F aksi} &= -\vec{F} \text{ reaksi} \\ \vec{F_{12}} &= -\vec{F_{12}} \\ m_1\vec{a_1} &= -(m_2\vec{a_2}) \\ \frac{m_1(\vec{v'_1}-\vec{v_1})}{\Delta t} &= -\frac{m_2(\vec{v'_2}-\vec{v_2})}{\Delta t} \\ m_1(\vec{v'_1}-\vec{v_1}) &= -m_2(\vec{v'_2}-\vec{v_2}) \\ m_1\vec{v'_1}-m_1\vec{v_1} &= -(m_2\vec{v'_2}-m_2\vec{v_2}) \\ m_1\vec{v'_1}+m_2\vec{v'_2} &= m_1\vec{v_1}+m_2\vec{v_2} \end{aligned} \quad (2)$$

**The Concept of Impulse in Physics**

Impulse occurs when a force acts on an object for a short time, producing a change in momentum. In the game of marbles, impulse occurs when a player flicks a marble with their finger, applying a force over a short period of time and causing a change in the marble's momentum.

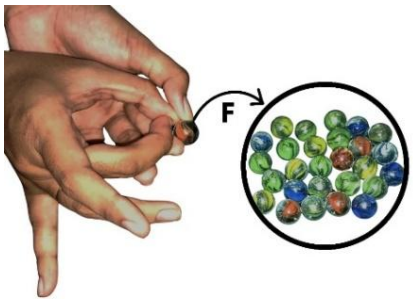


**Figure 4.** The force exerted by the marbles

Figure 4 illustrates the application of force by the player's finger when flicking the marble. The short contact time between the finger and the marble represents the impulse acting on the object, which subsequently changes the marble's momentum. A marble is initially at rest, and then the index finger applies a force to push it. When the index finger applies a force to the marble, the time interval during which the finger makes contact with the marble is very brief in order to hit the target marble. In physics, impulse is defined as the product of force and the time interval during which the force acts on an object.

$$I = F\Delta t \quad (3)$$

This equation shows that the greater the impact force or the longer the duration of the impact, the greater the impulse produced. This finding is consistent with the theory of impulse and the impulse–momentum relationship proposed.

**Table 3.** Explanation of the Concept of Impulse in the Traditional Game of Marbles

| No | Activities in the Marble Game | The Concept of Impulse | Explanation |
|---|---|---|---|
| **1** | The player flips the marble with a finger | Impulse | The force applied by the finger in a short period of time imparts momentum to the marble, causing it to start moving |
| **2** | The marble moves quickly toward the target | The effect of force on impulse | The greater the force applied by the player, the greater the momentum imparted, causing the marble to move faster |
| **3** | The marble hits the target marble | Change in momentum due to impulse | The collision causes a change in the marble's speed and direction of motion due to the |

| No | Activities in the Marble Game | The Concept of Impulse | Explanation |
|---|---|---|---|
| | | | momentum transferred during contact |
| **4** | The target marble moves after the collision | The relationship between impulse and the motion of an object | Greater momentum causes the target marble to travel farther |

Based on the observations, impulse in the traditional game of marbles is evident when a player applies a force to the marble using their finger in a brief instant, causing the marble to move toward the target. The greater the force applied or the faster the flick, the greater the impulse generated, resulting in a stronger movement of the marble. Impulse also causes changes in the speed and direction of the marble's motion after a collision occurs. This finding aligns with the theory of impulse, which states that impulse is influenced by the magnitude of the force and the duration for which the force acts on an object (Halliday, 2014).

In the traditional game of marbles, impulse can be observed when a strong collision causes the target marble to move farther than a weak collision does. The concept of impulse is also directly related to changes in an object's momentum.

$$I = \Delta p = m(v_t - v_0) \quad (4)$$

**Analysis of Collisions, Momentum, and Impulse in the Traditional Marble Game**

The traditional marble game demonstrates collision events related to the concepts of momentum and impulse. A collision occurs when a moving marble strikes another marble, causing a change in the marble's velocity or direction of motion. This phenomenon can be observed directly during the game and serves as a real-life example of the application of physics concepts in everyday life.

In the marbles game, momentum transfers from the moving marble to the target marble when a collision occurs. As a result, the target marble moves, while the speed of the striking marble decreases after the collision. Additionally, impulse occurs when a force acts for a brief moment during the collision, causing a change in the marbles' momentum. The relationship between impulse and change in momentum can be expressed as follows:

$$I = \Delta p \quad (5)$$

This equation shows that impulse is directly related to the change in an object's momentum. In a game of marbles, a marble moving faster results in a stronger collision, so the resulting change in momentum is also greater.

The phenomenon of collisions in the traditional game of marbles can help students understand the concepts of momentum and impulse more concretely through direct observation. Physics instruction linked to traditional games allows students to connect abstract concepts with real-life experiences, making learning more contextual and meaningful (Pratiwi et al., 2025).

The results of the observations also show that a fast-moving marble is able to move the target marble farther after the collision occurs. This phenomenon indicates a transfer of momentum from the striking marble to the target marble during the collision process. This finding aligns with the concept of momentum in physics, which states that momentum is influenced by an object's mass and velocity; thus, the greater the marble's velocity, the greater the momentum and impulse generated.

**The Relationship Between the Concepts of Momentum and Impulse in Physics Education**

The traditional game of marbles holds strong potential for connecting the concepts of momentum and impulse to physics education in schools (Mulyaningsih et al., 2023). Based on the observation results, the game activity demonstrates phenomena of motion and changes in

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velocity that can serve as a real-world context for explaining abstract concepts in physics. Momentum arises when the marble moves after a force is applied by the player, while impulse occurs when the player's finger applies a force to the marble for a brief moment. These phenomena provide a concrete illustration of the relationship between mass, velocity, force, and changes in momentum in the traditional marble game.

In addition, marbles can be used as a demonstration tool in physics education because students can directly observe the effects of mass and velocity on the motion of marbles. To reinforce the connection between the concepts of momentum and impulse in the traditional game of marbles, observations were made of the variations in marble size used during the game. The results of the observations show that variations in marble size affect the magnitude of the momentum and impulse generated during the game.

**Figure 5.** Size Variations in the Traditional Marble Game

Figure 5 demonstrates variations in marble sizes used during observation. Differences in marble mass influence the magnitude of momentum and impulse generated during collisions. Larger marbles tend to produce stronger collisions, whereas smaller marbles are more easily displaced after impact. Larger marbles have greater mass and therefore generate greater momentum than smaller marbles when moving at the same speed. Conversely, smaller marbles change direction more easily after a collision. In addition to affecting momentum, variations in marble size also affect the magnitude of the impulse that occurs during a collision. Marbles with greater mass tend to generate a stronger collision force, resulting in a greater impulse imparted to the target marble. These findings demonstrate a direct relationship between mass, momentum, and impulse in the traditional game of marbles.

**Table 4.** Results of observations on the effect of marble size on the concepts of momentum and impulse

| Marble Variation | Observation Results | Momentum and Impulse Analysis |
|---|---|---|
| Small marble | Moves faster but changes direction easily | Momentum and impulse are relatively small due to the smaller mass |
| Medium marble | Movement is more stable during collisions | Momentum and impulse are moderate, balancing mass and velocity |
| Large marble | Collisions are stronger and it is difficult to change direction | Momentum and impulse are greater due to the larger mass |
| Collision between a large marble and a small marble | The small marble is thrown farther away | The momentum and impulse of the large marble are more |

| Marble Variation | Observation Results | Momentum and Impulse Analysis |
|---|---|---|
| Collision between a small marble and a large marble | The large marble moves only slightly | dominant<br>The momentum and impulse of the small marble are smaller, so the impact of the collision is less significant |

The results of the observation show that mass and velocity have a direct effect on the magnitude of momentum and impulse in the traditional game of marbles. Larger marbles generate greater momentum because they have greater mass than smaller marbles. In addition, marbles moving at high speeds produce stronger collisions and are able to move the target marble farther. These conditions indicate that the greater the mass and velocity of an object, the greater the momentum and impulse generated during the collision. This finding aligns with the momentum equation, which states that momentum is determined by the product of an object's mass and velocity, while impulse is determined by the force and the duration of the collision.

Physics instruction linked to local culture can help make abstract concepts more tangible and easier to understand (Adelia et al., 2025). This finding is consistent with Rizki et al. (2022), who reported that stating that ethnophysics-based learning can enhance conceptual understanding because the instructional material is linked to cultural experiences closely tied to daily life. Additionally, the results of this study reinforce research Ningrum et al. (2025) indicating that traditional games incorporate physics concepts such as force, energy, momentum, impulse, and collision, which can be utilized as contextual learning resources. Integrating local culture into science education has been shown to strengthen the connection between learning materials and daily life (Septina et al., 2025). The game of marbles demonstrates that the concepts of momentum and impulse are not only learned theoretically but can also be directly observed in traditional game activities (Yetia et al., 2024).

The results of this study indicate that the traditional game of marbles can be used to explain physical phenomena through observation, analysis, and interpretation during gameplay, where the concept of momentum arises when marbles move due to forces applied by players, while the concept of impulse arises during collisions that cause changes in the marbles' velocity and direction of motion. Unlike previous studies such as Tharisth et al. (2025), which still focused on the general identification of physics concepts in traditional games, this study demonstrates that local culture can be integrated into physics education, making physics concepts more contextual to daily life (Lumbu et al., 2022). Based on the research results, the traditional marbles game not only functions as a cultural game but also contains scientific concepts relevant to physics learning, particularly the concepts of momentum and impulse. The implications of this study suggest that the traditional marbles game can be used as an ethnophysics-based learning resource to help explain the concepts of momentum and impulse in a contextual manner.

## CONCLUSION

This study demonstrates that the traditional marble game contains contextual representations of momentum and impulse concepts through the motion and collisions of marbles. The findings indicate that variations in marble mass and velocity influence momentum transfer and impulse during gameplay, making the game an effective ethnophysics-based learning resource. The findings have practical implications for physics education by providing teachers with an alternative contextual learning resource that integrates local culture into classroom instruction. The use of traditional games can help students understand abstract

concepts more concretely while simultaneously promoting cultural preservation. Nevertheless, this study has several limitations. The analysis was conducted qualitatively through observation and literature review without quantitative measurements of collision parameters such as force, collision duration, or coefficient of restitution. Therefore, future research is recommended to combine qualitative ethnophysics analysis with experimental quantitative measurements and to develop ethnophysics-based learning media that can be implemented directly in physics classrooms.

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## AUTHOR CONTRIBUTIONS

**Talitha Rizki Salsabila**: Conceptualization, Investigation, Data Curation, Writing – Original Draft, and Visualization; **Habibi**: Supervision, Validation, Methodology, Review & Editing, and Project Administration; **Luna Syarifa Nathania**: Resources, Documentation, Data Collection, and Investigation

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