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The Traditional Game of Pata-Pata: Uncovering Physics Concepts and Their Application in School Learning

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Abstract: Traditional games are a heritage that has existed since ancient times and has moral and scientific values. Along with the times, traditional games are played rarely by children in Maluku. This study aims to reveal the concept of physics in the traditional game of pata-pata in Wakal Village, Leihitu District, and its implementation to improve mastery of the material at SMA Negeri 18 Central Maluku. This research combines descriptive qualitative method to reveal the concept of physics and descriptive quantitative method to know the improvement of mastery of physics material in the traditional game of Pata-Pata. Data were collected through interviews, document study, test administration and observation of learning implementation. The data were then analyzed using qualitative descriptive and quantitative descriptive data analysis techniques using the N-Gain test. The results of data analysis show that the physics concepts revealed in traditional pata-pata games are bulk modulus, momentum, impulse, collision, sound, Boyle's law, and kinetic energy in the 2013 Curriculum and Merdeka Curriculum. The implementation of pata-pata games in learning the physics concepts of momentum, impulse, collision carried out using the CRT learning approach shows an increase in material mastery. A total of 60% of students experienced an increase in moderate qualifications and 30% of students in low qualifications. The average score of material mastery improvement is 0.21.

Keywords: Material Mastery; Pata-Pata; Physics Concepts; Traditional Games

Introduction

society is traditional games. In the current era of digital development, cultures in society have begun to fade, including traditional games (Ayanti et al., 2022). Traditional games are cultural heritage that have been played for a long time and then passed down from generation to generation (Ardiyanto, 2018). Traditional games need to be preserved because they contain moral values, such as honesty, unity, skill, and courage (Shofiyati, 2023). In addition, traditional games are closely related to several fields of science such as physics, so that the existence of traditional games can be maintained by being used as teaching materials by teachers (Afkarina et al., 2023).

Preservation of traditional games needs to be done to prevent the fading of national culture, in addition, with the preservation of traditional games, social interaction and interaction with the environment are maintained (Damayanti et al., 2023). Several relevant studies have been conducted related to traditional games which were then implemented into physics learning, including the

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game of sliding using areca palm fronds, the belang boat in the Banda Islands, and the traditional game of bekleng in Hitu Village which is related to the concept of motion (Prasetyo, 2020; Yulan, 2020; Yunita, 2020), and the traditional crazy bamboo game which is related to the concept of effort, energy and movement (Limba et al., 2023). The traditional game of kanikir in Hitu Village, and the traditional game of boi in Allang Village, which are related to the concepts of momentum, impulse, and collision (Limba et al., 2023).

In Maluku Province, Central Maluku Regency, precisely in Wakal Village, there is one of the traditional games known as pata-pata. This game in the digital era has begun to be forgotten, because children prefer to play games on smartphones rather than pata-pata. The pata-pata game can actually be integrated into physics learning. This is in line with this study, namely revealing the physics concept behind the traditional pata-pata game and its implementation in the learning process.

The pata-pata game is closely related to the concept of bulk modulus, momentum, impulse, collision, sound, and kinetic energy. To apply the pata-pata game in physics learning, a suitable learning approach is used, namely Culturally Responsive Teaching (CRT). CRT is a learning approach that uses the culture and experience of students to create more meaningful learning (Girsang et al., 2024; Inayah et al., 2023). The purpose of this study is to reveal the physics concepts contained in the traditional pata-pata game and to develop its learning implementation to improve mastery of physics material at the secondary education level. By integrating science concepts into traditional games, this study aims to provide an alternative learning approach that is more contextual and based on local culture

Method

This research uses the educational development model fromPlomp, (1997), as shown in Figure 1.

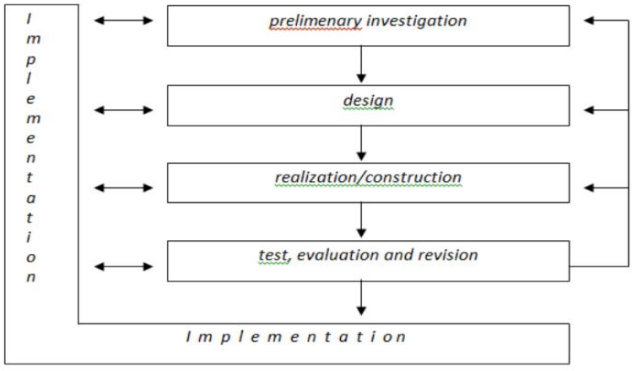

Figure 1. General Model for Solving Educational Problems (Source: Plomp, 1997)

Information:

Development Activities

Development stage activity flow

The flow of reciprocal activities between the development and implementation stages of ongoing learning models.

Development activity cycle

The development process begins with Step 1) Preliminary investigation. At this stage, information is collected related to the traditional pata-pata game in Wakal Village, Leihitu District, Central Maluku Regency, identification of physics concepts related to this game and how to implement it in a teaching module with a CRT approach; 2) Design. The activities carried out at this stage are designing documents and the necessary instruments; 3) Realization/construction. This stage is a continuation of the activities at the design stage which produces prototype 1 (initial) as the realization of the results of the design of an integrated physics teaching module for the traditional pata-pata game using the CRT approach; 4) Test, evaluation, and revision. At this stage, 2 main activities are carried out, namely (a) validation activities by experts related to physics content and learning; and (b) conducting a field trial of the prototype model results of the validation in class XI IPA SMAN 18 Central Maluku. At this stage, an analysis of the increase in mastery of the material according to the teaching module is also carried out.

Qualitative data collection was conducted through interview techniques, observation, and document studies. In addition, quantitative data collection was conducted through initial and final tests. The instruments used to collect data were interview guidelines, document studies, complete teaching modules, test instruments and observation guidelines. Before being used, these instruments have also been validated by experts and practitioners.

After the data was collected, it was then analyzed using qualitative descriptive data analysis techniques to reveal the physics concepts contained in the traditional pata-pata game, and a mapping of the 2013 Curriculum and Merdeka Curriculum concepts was carried out. Meanwhile, quantitative data was analyzed to provide an overview of the increase in students' mastery of the material after the learning process using the N-Gain equation according toHake, (2002)as shown in equation 1.

$$N - Gain = \frac{skor\ posttest - skor\ pretest}{skor\ maksimal - skor\ pretest} \quad (1)$$

Result and Discussion

Traditional Pata-Pata Game

Based on observations and interviews conducted in Wakal Village, it was found that pata-pata is one of the

games played by children. According to the informant, the traditional pata-pata game has existed since long ago in Wakal Village and is an ordinary traditional game because there is no special meaning and purpose in it.

The tools and materials used are bamboo and guava flowers. The type of bamboo commonly used is thorny bamboo or baduri bamboo, this is because according to the source, this bamboo is thicker and stronger. Guava flowers themselves are used as ammunition or bullets used when playing pata-pata, so this game is only played once or twice a year following the flower cycle of the guava tree. However, apart from guava flowers, children in Wakal Village also use newspapers that is moistened with water and then rolled up to be used as ammunition or bullets for pata-pata. The manufacturing procedure begins with taking bamboo and cleaning it, then the bamboo is cut along one segment with the end of the bamboo segment cut and used as a support. Then another bamboo is cut into a stem with the same diameter as the bamboo hole that was previously cut, after which the bamboo stem is attached to the end of the previously cut bamboo segment and used as a guava flower pusher in pata-pata. The number of players is unlimited so that it can be played by many people by attacking and shooting each other using pata-pata.

In addition to data obtained through interview techniques and direct observation, there is also secondary data obtained through document study techniques. After conducting a document study, several physics concepts were revealed and identified. In addition, these physics concepts can be used for classroom learning, both for junior high and high school levels using the 2013 Curriculum and the Merdeka Curriculum.

Results of Identification of Physics Concepts in the Traditional Pata-Pata Game

Based on the results of interviews and document studies conducted, several physics concepts were revealed in the traditional pata-pata game. The following is a detailed explanation.

Bulk Modulus

Bulk modulus is a parameter used to describe the stiffness or elasticity of a material when subjected to pressure from all directions (Iriyanto et al., 2025). In this context, stress refers to the force applied to a material per unit area. Bulk modulus measures the extent to which a material can change in volume when stressed (Giancoli, 2005). The concept of bulk modulus occurs in the pata-pata game when the guava flower is pressed in the bamboo cavity, so that the volume of the guava flower will decrease. When the guava flower comes out of the bamboo cavity, the pressure will disappear so that the guava flower will bounce while returning to its original volume (Figure 2.).

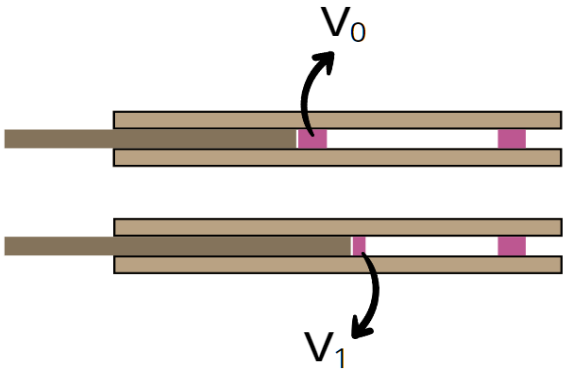

Figure 2. The concept of bulk modulus in the traditional game of pata-pata

Before being pressed, the length of the guava flower is L (when inserted into the end of the pata-pata cavity). When pressed, the length of the guava flower decreases by ΔL. Suppose the cross-sectional area of the bamboo cavity is A, then the initial volume of the guava flower is

$$V_0 = AL \tag{2}$$

The change in volume of guava flowers when pressed is

$$\Delta V = A\Delta L \tag{3}$$

The force acting on the guava flower that changes the volume is the friction force by the bamboo wall, f. The bulk modulus of the guava flower satisfies the equation

$$B = \frac{-f/A}{\Delta V/V_0} \tag{4}$$

Momentum

Momentum is a concept in physics that describes how difficult it is to stop or change the movement of an object, because large momentum tends to be difficult to stop or change, and conversely low momentum is easier to stop (Borotian et al., 2025). Momentum in the pata-pata game occurs when the guava flower in the bamboo cavity is pushed with a certain force so that the guava flower moves out of the bamboo cavity at high speed. The guava flower will move several meters or hit something, after which the guava flower will stop. The concept of momentum in pata-pata can be seen in Figure 3.

Figure 3. The concept of momentum in the game of pata-pata

Momentum is generally expressed as the result of multiplying mass by its velocity, which can be seen in equation 5.

$$\vec{p} = m\vec{v} \quad (5)$$

Where,

$\vec{p}$ = guava flower momentum (kg m/s)
m = guava flower mass (kg)
$\vec{v}$ = guava flower speed ()m/s

Impulse

Impulse is how much an external force changes the momentum of an object (Budiarti et al., 2023). In the pata-pata game, the impulse acting on the bamboo is caused by the impulsive force (F) from the hand that pushes the bamboo stalk in a very short time interval (Δt) so that the guava flower in front is pushed and shoots quickly (Figure 4.)

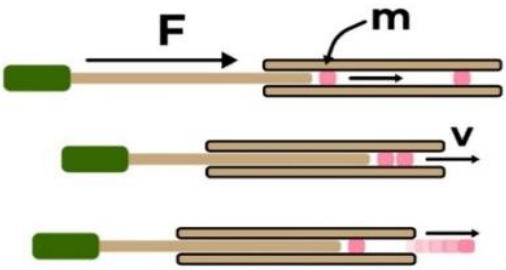

Figure 4. The concept of impulse in the game of pata-pata

The process that occurs in Figure 4 can be written in equation 6.

$$I = \Delta p = p_{akhir} - p_{awal} \quad (6)$$

Or

$$\bar{F} \cdot \Delta t = mv_{akhir} - mv_{awal} \quad (7)$$

Where,

I = Impulses acting on guava flowers(N s or kg m/s)
Δp = The change in momentum experienced by a guava flower after being hit by another guava flower (*kg m/s*)
$\bar{F}$ = The average impulsive force exerted by one guava flower on another guava flower upon contact (*N*)
Δt = The time interval when contact occurs between guava flowers ($t_2 - t_1$) (s)
m = Guava flower mass (kg)
v = Guava flower speed (m/s)

Collision

A collision is an event where two moving objects meet and the law of conservation of momentum applies (Mughny, 2016). In the concept of collision, there is a term for collision elasticity, which is the rebound of two objects after the collision process occurs. In the pata-pata game, the collision event occurs when a bullet that shoots out of the bamboo cavity hits a surface of an object or the opponent's body and bounces in the opposite direction to its original direction. The collision that occurs in the pata-pata game is a partial elastic collision. Partial elastic collisions occur because the speed of the guava flower before the collision process is different from the speed of the guava flower after the collision process occurs as shown in Figure 5.

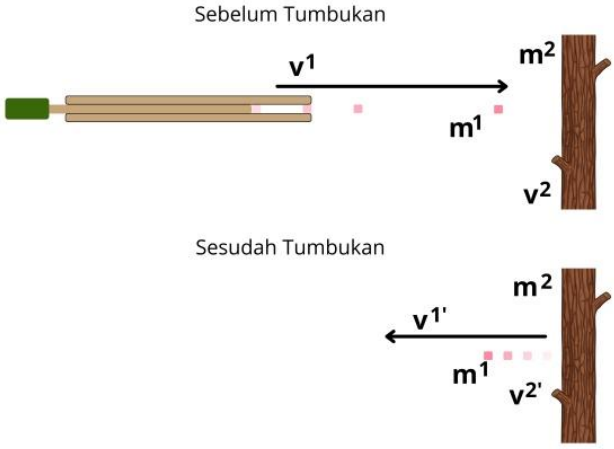

Figure 5. The concept of collision in the game of pata-pata

The collision event in Figure 4 can be written in equation 8.

$$m_1 \cdot v_1 + m_2 \cdot v_2 = m_1 \cdot v_1' + m_2 \cdot v_2' \quad (8)$$

Where,

m_1 = Guava flower mass(kg)
m_2 = Mass of object (kg)
v_1 = Speed of guava flower before impact (m/s)
v_2 = The speed of other objects before the collision (m/s)
v_1' = Speed of guava flower after collision (m/s)
v_2' = The speed of other objects after the collision (m/s)

Sound

Sound in physics is a longitudinal wave that propagates through a certain medium (Sugianta, 2020). Sound occurs due to changes in air pressure around the sound source, and these pressure changes are in the form of compression and expansion of air particles (Wibwo & Purwanto, 2016). When playing pata-pata, it will certainly produce sound, and the sound comes from the difference in air pressure between behind the guava flower when it is in the bamboo and the air pressure in the atmosphere as shown in Figure 6.

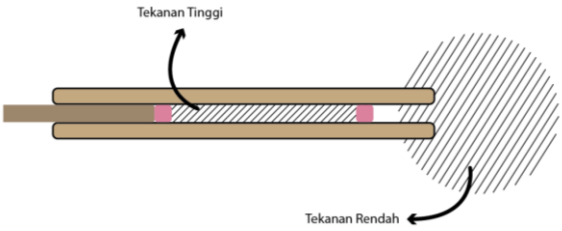

Figure 6. Difference in air pressure on the walls

After the guava flower is pushed out of the bamboo cavity, the high-pressure air behind the guava flower will meet the low-pressure air outside the bamboo cavity. This event is what causes the sound when playing pata-pata as shown in Figure 7.

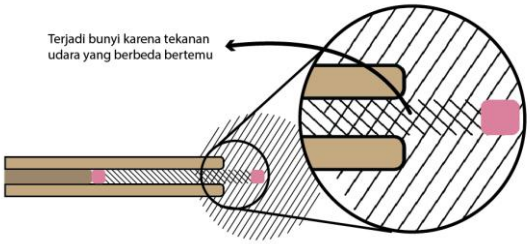

Figure 7. The process of sound production in the pata-pata

The size of the sound produced by*pata-pata*influenced by the diameter of the bamboo used. The smaller the diameter of the bamboo, the louder the sound produced, this is because the smaller the area of the pressure field, the greater the pressure produced, this is in accordance with Boyle's law which states that if the temperature of a gas in a closed room is kept constant, then the gas pressure will be inversely proportional to its volume. This means that the smaller the volume of the room, the greater the air pressure produced or vice versa(Dhamayanthie & Nugroho, 2018; Kua & Bakti, 2021).

$$P_1 \times V_1 = P_2 \times V_2 \quad (9)$$

Where,

P_1 = Air pressure in bamboo cavity(N/ or Pa, or atm)m^2

P_2 = Air pressure around the end of the bamboo cavity(N/ or Pa, or atm)m^2

V_1 = Volume of bamboo cavity ()m^3

V_2 = Air volume around the end of the bamboo cavity()m^3

Kinetic Energy

Kinetic energy is the energy possessed by an object due to its movement (Rahmawati & Malik, 2024; Sulaiman & Tegar, 2019). Kinetic energy comes from the Greek word kinetos which means moving.(Fariha, 2021). In the game of pata-pata, kinetic energy is possessed by the guava flower.

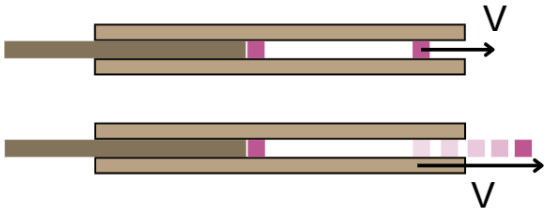

Figure 8. The process of momentum in the game of pata-pata

The guava flower that is pushed out of the bamboo cavity will shoot at a certain speed so that the guava flower will have some kinetic energy due to its movement (Figure 8). This phenomenon can be written in equation 10.

$$E_K = \frac{1}{2} m \cdot v^2 \quad (10)$$

Where,

E_K = The kinetic energy possessed by guava flowers(Joules)

m = Guava flower mass(kg)

v = The speed of the guava flower when it comes out of the end of the bamboo cavity ()m/s

Mapping of KD and CP of Traditional Pata-Pata Game

Based on the results of the identification of the concepts of Science-Physics that have been carried out, these concepts need to be mapped to clearly describe the boundaries of the concepts of Science-Physics according to the curriculum for junior high school (SMP) and senior high school (SMA). The results of the mapping of KD (Basic Competencies) and CP (Learning Achievements) can be seen in Table 1.

Table 1. Mapping of KD and CP of the traditional pata-pata game

Draft	Curriculum			
	Curriculum 2013		Independent Curriculum	
	Junior High School	Senior High School	Junior High School	Senior High School
Bulk Modulus	-	Grade 10 Semester 1, KD 3.2 Analyzing the elastic properties of materials in everyday life	-	Phase F, Students are able to apply the concepts of kinematics and dynamics of motion.
Impulse	-	Grade 10 Semester 2, KD 3.10 Applying the concept of momentum impulse, as well as	-	Phase F, Students are able to apply the concepts of

Draft	Curriculum 2013		Curriculum Independent Curriculum	
	Junior High School	Senior High School	Junior High School	Senior High School
		the law of conservation of momentum in everyday life		kinematics and dynamics of motion.
Momentum	-	Grade 10 Semester 2, KD 3.10 Applying the concept of momentum impulse, as well as the law of conservation of momentum in everyday life	-	Phase F, Students are able to apply the concepts of kinematics and dynamics
Sound	Grade 8 Semester 2, KD 3.8 Analyzing the concept of vibrations, waves and sound in everyday life including the human hearing system and the sonar system in animals	Grade 11 Semester 2, KD 3.10 Applying the concept of sound and light in technology	-	Phase F, students are able to apply the concepts and principles of sound and light waves.
Boyle's Law	-	Grade 11 Semester 1, KD 3.4 Applying fluid dynamics in technology	-	Phase F, students are able to apply the concepts and principles of fluid dynamics.
Kinetic Energy	Grade 7 Semester 1, KD 3.5 Analyzing the concept of energy, various energy sources, and changes in energy forms in everyday life including photosynthesis	Grade 10 Semester 2, KD 3.9 Analyzing the concept of energy, effort (work), the relationship between effort and energy changes and their application in everyday events.	-	Phase F, Students are able to apply the concepts of kinematics and dynamics of motion.

Implementation of Pata-Pata Game in Learning at State Senior High School 18 Central Maluku

Game implementation*pata-pata*in learning at SMA Negeri 18 Maluku Tengah is carried out using the Culturally Responsive Teaching (CRT) approach in the Discovery Learning model. The CRT approach is used to connect learning with physics concepts contained in the pata-pata game. Learning begins with students watching a video of the pata-pata game, then they identify problems related to physics concepts. After that, students make hypotheses, then students discuss in groups and look for information and work according to the LKPD. In the last step, students make conclusions about the concepts of momentum, impulse, and collision in the Pata-Pata game. The initial and final mastery of the material by students is shown in Table 2.

Table 2. Data on Student Mastery of Initial, During and Final Material

Mastery Level	Initial Material Mastery		Final Material Mastery		Material Mastery Criteria
	f	%	*f*	%	
80 – 100	-	-	-	-	Very good
70 – 79.99	-	-	1	10	Good
60 – 69.99	2	20	2	20	Pretty good
40 – 59.99	2	20	7	70	Not good
0 – 39.99	6	60	-	-	Very Less
Amount	10	100	10	100	
Average		37.5		52	

The data in Table 3. Shows that before the learning process using the CRT approach integrated with the pata-pata game, 60% of students had very poor mastery criteria for momentum, impulse, and collision materials, 20% were not good and 20% were quite good, were in the qualification of failing because they had not mastered the momentum, impulse, and collision materials with an average material mastery score of 37.55. After the learning process took place, the mastery of momentum, impulse, and collision materials of students according to the criteria was 70% not good, 20% were quite good and 10% good with an average of 52. Overall, the mastery of the material at the beginning and end of learning is shown in Figure 9.

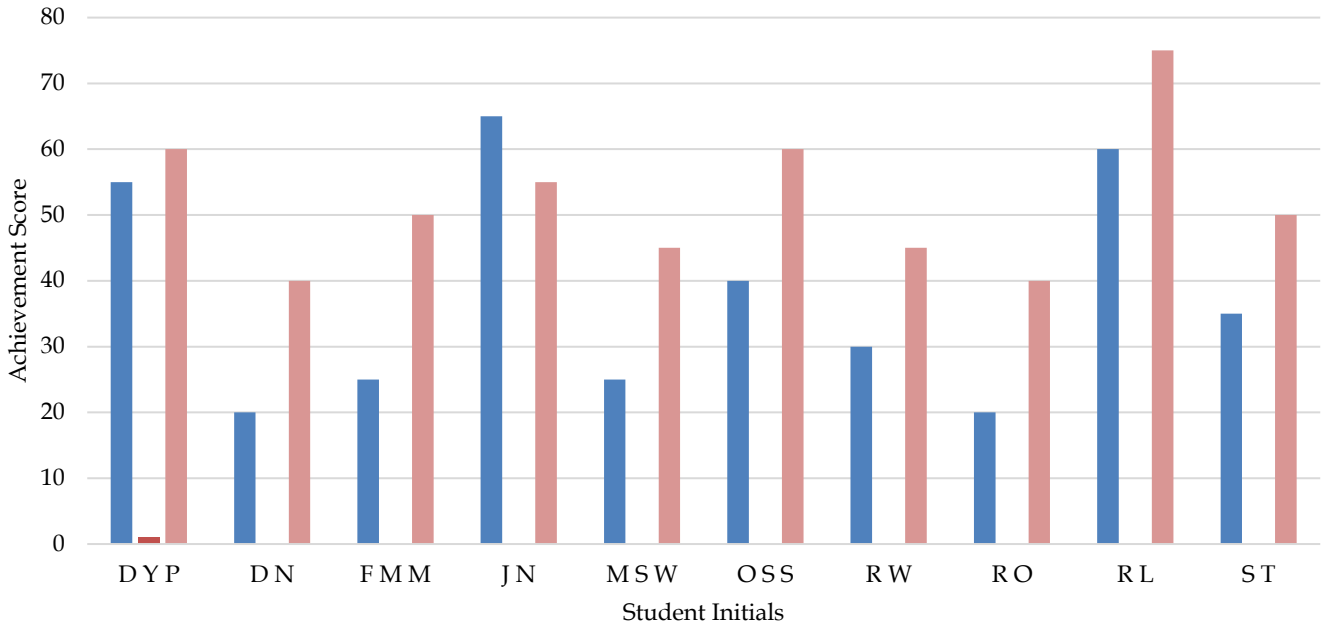

Figure 9. Achieving mastery of momentum, impulse & collision material

In Figure 9, the students' initial mastery of the material before the learning process took place was mostly in the very low criteria. The low initial test results were because they did not yet have in-depth initial knowledge about the momentum, impulse, and collision materials that would be taught. This is in line with the opinion of Muammar et al. (2015), that the low initial test results were because students did not have sufficient initial knowledge.

After the learning process was completed, a final test was conducted, and data was obtained that the students' mastery of the material was no longer in the very poor criteria. Students have been able to master the material on momentum, impulse, and collision, although most of them are still in the poor criteria. There are 20% of students who master the material quite well and 10% are good. The first reason why students still have a material mastery criterion that is not very good is because of the short learning time. The short learning time makes the material received by students not optimal to remember, and this is in line with the opinion of Zhan et al. (2018)that by learning repeatedly it will be easier to remember for a long period of time. In addition to the duration factor, another cause is that students are not yet accustomed to learning with the application of traditional games in learning. Integration of traditional games in science learning requires adaptation, because students are generally not accustomed to connecting academic concepts with their cultural experiences. Therefore, a systematic approach is needed so that students can understand the relationship between games and the scientific concepts being studied (Laksana et al., 2021).

To find out the increase in mastery of momentum, impulse, and collision material after students have learned using the CRT approach integrated with the pata-pata game, the N-Gain score equation is used using pretest and posttest score data and is interpreted as can be seen in Table 4 (Hartati, 2016).

Table 3. N-Gain Score Qualification

Mastery Level	Frequency	Percentage (%)	Qualification
$g \geq 0.7$	-	-	Tall
$0.3 < g < 0.7$	6	60	Currently
$g \leq 0.3$	4	40	Low
Average N-Gain Score = 0.21			Low

The results of the analysis of the increase in mastery of the material using the N-Gain equation in Table 4 show that 60% of students experienced an increase in mastery of momentum, impulse, and collision material using the integrated CRT approach of the Pata-Pata game at medium qualifications, and 40% of students experienced an increase in mastery of the material at low qualifications. The increase in mastery of the material achieved by each student can be seen in Figure 10.

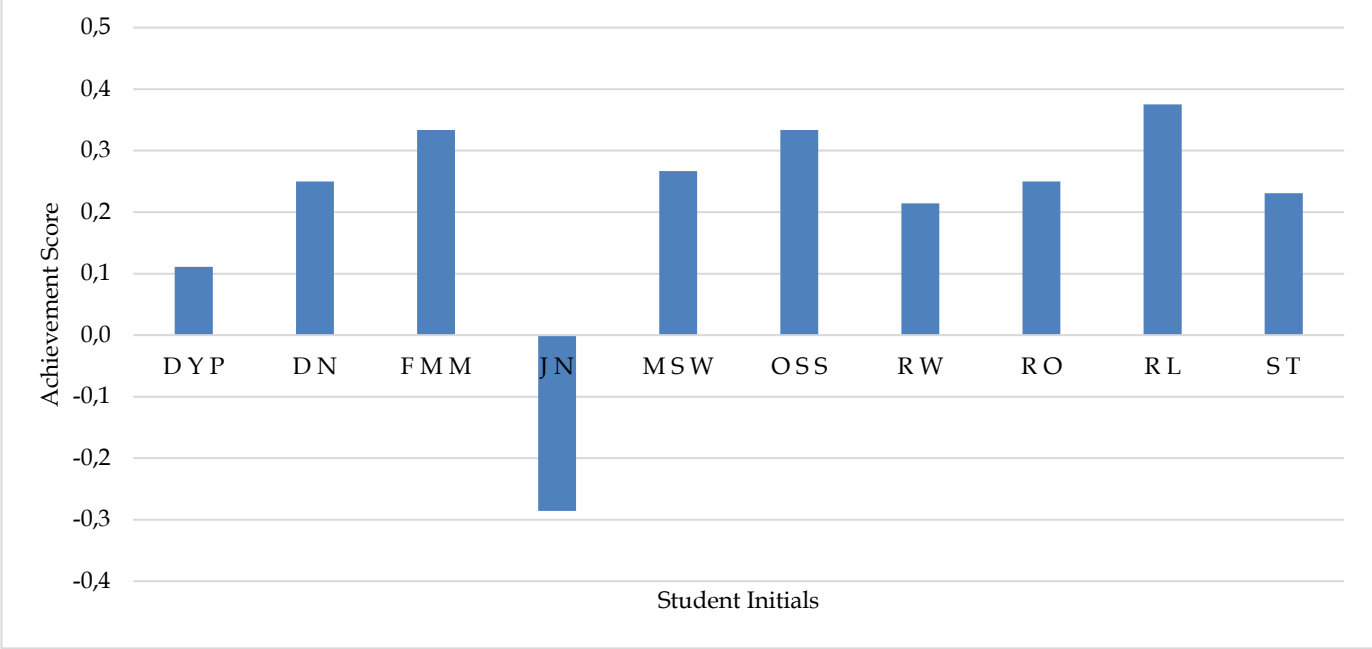

Figure 10. Improved mastery of momentum, impulse and collision materials

Data analysis of the increase in mastery of the material shows that there are 9 (90%) students who experienced an increase in mastery of momentum, impulse, and collision materials. As many as 6 (60%) students experienced an increase in medium qualifications, and 3 (30%) students experienced an increase in mastery of the material at low qualifications. Figure 9 shows that there is 1 student who experienced a decrease. This is because during the initial test, the answers given were random so that the initial test score was higher than the final test and caused the N-Gain test results to decrease. Meanwhile, the increase in mastery of the material after the learning process was because students were familiar with how to play pata-pata so that it was easy to identify the concepts of momentum, impulse, and collision in it. According to Yolanda et al. (2024), direct experience in meaningful activities can help students build a deeper understanding of concepts. By knowing how to play pata-pata, students can more easily connect their playing experiences with physics concepts such as momentum, impulse, and collision. This is shown by the results of the researcher's observations during the learning process which show that students tend to actively answer when asked questions about the process of playing pata-pata. Social interaction in games can be an important factor in cognitive development, because students learn through direct experience and discussions with peers (Hariyono et al., 2024).

Overall, the learning process using the integrated CRT approach of the Pata-Pata game went well, and the response from students was also good. However, it is necessary to follow up on the shortcomings in learning such as the need for introduction of learning models or approaches so that students understand better and can follow the learning well. In addition, the number of learning meetings must also be increased so that learning materials can be provided more clearly. In line with that, Kristianti et al. (2024)revealed that a longer, more gradual learning process allows students to understand concepts more deeply through repeated experiences.

Conclusion

Based on the results of the analysis and discussion related to the physics concept in the traditional pata-pata game, it can be concluded that there are physics concepts, namely bulk modulus, impulse, momentum, sound and kinetic energy. The traditional pata-pata game needs to be preserved and maintained. One way to preserve is by connecting local knowledge and modern science to be integrated into physics learning in schools. The application of learning using the CRT approach integrated with the Pata-Pata game at SMA Negeri 18 Central Maluku showed an increase in student mastery of the material. As many as 60% of students experienced an increase in material mastery in medium qualifications, and 40% of students experienced an increase in material mastery in low qualifications. The response of students to the learning process using the CRT approach integrated with the Pata-Pata game was also good, so one way to preserve local culture is to apply it to learning in schools.

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Author Contributions

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Conflicts of Interest

There is no conflict of interest in this writing process.

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