Volume 12. Number 2. 195-216 NOVEMBER 2023

Jurnal Ilmiah Pendidikan Fisika Al-BiRuNi
https://ejournal.radenintan.ac.id/index.php/al-biruni/index
DOI: 10.24042/jipfalbiruni.v12i2.18234

P-ISSN: 2303-1832
e-ISSN: 2503-023X

An Exploration of Physics Concepts in *Pletokan* (*Luthang*) Traditional Game: What is the Potential of a Physics Learning Media in the Merdeka Belajar Curriculum?

Afaurina Indriana Safitri[1], Setyo Admoko[1*], Nadi Suprapto[1], Rahmah Trinita Putri[1], Hanan Zaki Alhusni[1]

[1] Physics Education, Universitas Negeri Surabaya

**Corresponding Address: setyoadmoko@unesa.ac.id*

Article Info

Article history:

Received: July 29, 2023
Accepted: October 17, 2023
Published: November 29, 2023

Keywords:

Learning Media;
Local Wisdom;
Physics Learning;
Pletokan;
Traditional Games.

ABSTRACT

This research explores physics concepts in depth in *pletokan* to be integrated into physics learning in the Merdeka Belajar curriculum. Using a qualitative descriptive approach and data triangulation techniques (observation, interviews, and literature study), this research identified *pletokan* as a superior contextual media for learning physics. Effectively achieve the learning objectives of the Merdeka Belajar curriculum while providing an enjoyable educational experience. The exploration results obtained specifically show that the traditional game of *pletokan* involves various physics principles such as gravitational potential energy, friction force, work and energy, ideal gas compression, bulk modulus, sound waves, motion dynamics, parabolic motion, and partially elastic collisions. These findings highlight the potential of *Pletokan* as a promising ethnoscience-based medium for physics learning, which is beneficial in improving student motivation and academic outcomes. Further research is needed to validate advanced applications and their effectiveness in improving student learning outcomes. Embracing ethnoscience in this way enriches students' understanding by including context and preserving the nation's cultural heritage.

INTRODUCTION

Current learning has shifted from the 2013 curriculum to the Merdeka Belajar curriculum, which places more emphasis on aspects of character development and student soft skills (Cahyono, 2022; Hadi et al., 2023; Irawati et al., 2022; Satiti & Falikhatun, 2022; Solikhah & Purnomo, 2022). In addition, it should be noted that the Merdeka Belajar curriculum focuses on presenting relevant, essential, and in-depth material to build students' creativity (Sihombing et al., 2021). The Merdeka Belajar curriculum was created to provide a pleasant learning atmosphere for students and teachers (Rindaningsih et al., 2023; Sihombing et al., 2021). Because, in essence, the Merdeka Belajar curriculum was created to give students the freedom to determine their interests and talents (Maipita et al., 2020; Pertiwi & Pusparini, 2021; Supriani et al., 2022). Thus, it will facilitate the process of achieving existing learning objectives.

Thus, a supporting tool is needed to realize the goals of the Kurikulum Merdeka. One way that can be applied to create a pleasant learning atmosphere is to use learning media (Puspitarini & Hanif, 2019).

Appropriate learning media is needed to optimally support students' interests and talents in the recovery period (the transition period for changing the curriculum) (Hadi et al., 2023). Good learning media is learning media adapted to students' circumstances or backgrounds and their learning environment (Pratama & Retnawati, 2018; Rahmatullah &

How to cite Safitri, A. I., Admoko, S., Suprapto, N., Putri, R. T., & Alhusni, H. Z. (2023). An exploration of physics concepts in pletokan (Luthang) traditional game: What is the potential of a physics learning media in the *merdeka belajar* curriculum?. *Jurnal ilmiah pendidikan fisika Al-Biruni, 12*(2), 195-216.

Ghufron, 2021; Selwyn et al., 2020; Widodo, 2018). Bearing in mind that learning media used in learning activities will provide relatively large benefits (Febrianto et al., 2020; Lawrence & Tar, 2018; Molina et al., 2018). Therefore, appropriate learning media is very important for facilitating and achieving learning goals (Dwijayani, 2019; Hamilton et al., 2021; Sobaih et al., 2020).

Learning media itself is a tool used in achieving educational goals, a means for educators to transfer knowledge, as well as a learning tool for students (Alfalah, 2018; Rapanta et al., 2020; Widodo, 2018; Windschitl et al., 2020). One of the learning media needed in the Merdeka Learning curriculum is visual aids (Mairizwan et al., 2022; Novia et al., 2023). One example of teaching aids media is that it can be found in traditional games (Alam, 2022). Traditional games as learning media, besides being contextual and able to create a pleasant atmosphere during learning, also preserve local culture (Widiana et al., 2018).

Traditional games are Indonesian local wisdom passed down by ancestors to the next generation (Kurniawan et al., 2022; Sulistyaningtyas & Fauziah, 2019). Traditional games contain high cultural values and are a national cultural heritage that must be preserved (Balletti et al., 2017; Thalib & Ahmad, 2020; Wahyuni et al., 2019; Widiana et al., 2018; Yang et al., 2018). Children play traditional games uniquely, depending on each region (Anggita, 2018; Gomme, 2020). In addition, it should be noted that traditional games vary from one region to another so that they can be used as a source of knowledge, one of which is physics (Aisyah, 2017; Fatmawati, 2021; Wulansari & Admoko, 2021). Traditional games are closely related to physics concepts, such as during operation (Lai et al., 2018; Thalib & Ahmad, 2020). Traditional games are identically operated by making physical contact between players and their props, like pulling, pushing, or other types of business (Dixon et al., 2018). The process of operating traditional games varies from region to region due to various factors such as community habits, thick traditions, and the potential for abundant natural resources in the area concerned (Sulistyaningtyas & Fauziah, 2019). One type of traditional game that utilizes the potential of abundant natural resources is *pletokan* (Komariah & Salim, 2019; Lathifah et al., 2019).

Pletokan is a traditional game that uses old bamboo sticks (the condition of the bamboo used has an impact on the resilience of *pletokan*) as a raw material for *pletokan* frames (Abdulfattah & Putranta, 2020; Ali & Aqobah, 2021; Hadjarati et al., 2021; Sukaesih et al., 2022). This game uses round grains or pulp as bullets (Intani, 2021; Silaban & Bhaskaraa, 2020). This game originates from Betawi, which is played in a certain way by the community and has differences in the mention of names and game rules from other regions (Fitri et al., 2020; Ma'arif, 2021). In general, *pletokan* games are played by children either in groups or individually (Zayyadi et al., 2018). This game was carried out in groups to create a scene during a war (Pratiwi, 2020). At the same time, *pletokan* is played individually when the community uses it as a weapon to hunt small animals.

Pletokan is played by pulling a bamboo stick and pushing the bat until two bullets come out of the *pletokan* casing. The first bullet is near the attacker's end, and the second bullet is at the end of the *pletokan* sheath (Regiana, 2018). The exit of bullets previously in the *pletokan* casing is marked by a "*pletok*" sound (Sunimastuti, 2020). The sound is formed due to the pressure between the *pletokan* shroud and the bullet inside. In addition to the sound heard, *pletokan* bullet seeds can cause pain when they hit the opponent's body. The faster the shovel is pushed, the more painful the bullet will hit the opponent's body. Therefore, the process of playing *pletokan* requires the right skills and strategies to achieve the goals of the game being played.

Pletokan games can train the affective, psychomotor, social skills, and problem-solving skills of someone when faced with a problem in-game activities (Marlina & Pransiska, 2017; Moore, 2017; Warmansyah et al., 2021). However, it should be noted that as time goes on, this game is increasingly being abandoned by children because it has been replaced by games that are more sophisticated in today's era (Eskasasnanda, 2017; Susanto, 2017; Thalib & Ahmad, 2020). What's even worse is that some children nowadays have never played it and don't know about this type of traditional *pletokan* game (Dewi & Alam, 2020; Trajkovik et al., 2018).

One effort that can be implemented to preserve traditional *pletokan* games as a cultural heritage is to integrate these games into learning activities, including physics (Anwar et al., 2018; Rizki et al., 2022). This is because the process of playing traditional *pletokan* games contains a close relationship with physics concepts. Therefore, when *pletokan* is integrated into physics learning, it will provide contextual learning. This has the intention that the learning carried out can make it easy for students to understand the material because it is related to things that happen in everyday life for students (Laurens et al., 2017; Shadiev et al., 2017). In addition, learning physics that is integrated into a traditional game can provide entertainment for students so that it is easier to deepen existing concepts and increase their learning motivation (Aisyah, 2017; Baran et al., 2018; Chen et al., 2021; Lin et al., 2018).

Integrating *pletokan* games into learning physics is a form of ethno-physics (Saphira et al., 2022). Through this ethno-physics-based learning process, students are expected to better understand physics concepts and participate in efforts to preserve national culture (Anthony, 2017; Laila et al., 2021; Suastra & Pujani, 2021). Therefore, this study aims to explore the physics concepts of the traditional *pletokan* game in more detail. This research has an update of an in-depth exploration of physics concepts in traditional *pletokan* games that have not been identified in previous studies. This is because previous research only focused on using *pletokan* as a medium for learning physics without exploring physics concepts in depth, and in previous research, *pletokan* only studied its integration with mathematics (ethnomathematics) (Abdulfattah & Putranta, 2020; Zayyadi et al., 2018). Thus, the results of this study are expected to provide convenience for students in understanding physics concepts in depth and maximizing efforts to preserve Indonesian local culture.

METHODS

This study uses a qualitative descriptive approach by integrating an exploratory design to map an object relatively (Almeida, 2018; Queirós et al., 2017). The exploratory design in this study reflects the in-depth exploration of physics concepts in *Pletokan* games. The stages in the research process can be seen in Figure 1 below in more detail.

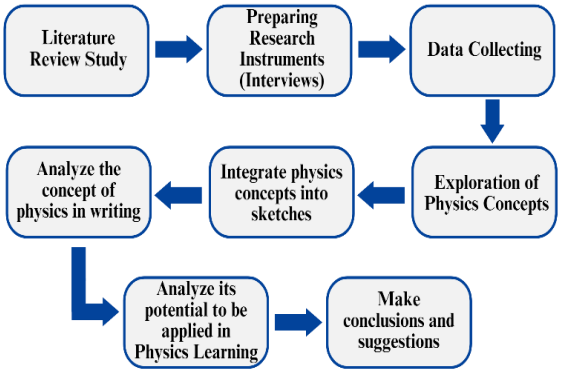


Figure 1. Research Phase Flow (Rizki et al., 2022)

Before collecting data, the researcher conducted a literature review study to strengthen the problem description and then prepared an interview instrument. A literature review was carried out by looking for some credible literature that had been made by previous research so that it had a positive impact in the form of increasing and opening the perspective of researchers (Calabrò et al., 2019; Errandonea et al., 2020; Garousi et al., 2019; Wang et al., 2019). Where the literature used must be by the topic being studied, in other words, the literature

review is a technique that is applied to finding ideas or reliable reference sources in research activities, so that it will make it easier for researchers to prepare research instruments (Cooper et al., 2019; Snyder, 2019).

The data collection technique in this study was carried out using the purposive sampling method. The purposive sampling technique was used because it is easier to determine an appropriate sample based on criteria based on research needs and time used more effectively (Campbell et al., 2020; Etikan & Bala, 2017; Klar & Leeper, 2019). The sample was from two Physics Education Study Program students at Surabaya State University. The sample was chosen because the researcher was familiar with and knew the characteristics of the sample, so access to in-depth information was easier. Apart from that, the samples met criteria such as understanding physics concepts in detail (both samples came from the physics study program, so they were familiar with physics concepts), and the samples were familiar with and had played *pletokan* games before. In this way, the suitability and completeness of the data will be obtained during the research process.

The interview was conducted on March 22, 2023. The interviews were conducted alternately, were structured, and used the same questions for the two samples. The interview instrument was prepared using everyday language to make it easier for the interviewees to capture the intentions desired by the researcher (Roberts, 2020). The list of questions made is adjusted to the physics concepts that are by the *pletokan* game based on the views of the researchers. The data collection process is carried out in a structured manner by involving a simulation process in playing *pletokan* for further documentation. After the research data is obtained, explore physics concepts in depth and visualize these physics concepts in graphic design. Then, the data is strengthened using literature studies to obtain relevant information in more depth (literature studies provide references to researchers in strengthening the analysis and obtaining more information based on relevant previous research).

After the three data from the three data collection models were obtained, data triangulation was carried out to strengthen the findings (Farquhar et al., 2020; Nielsen et al., 2020). Data triangulation was done by combining the three data obtained through different methods during the research (Liu et al., 2018; O'Donovan & McAuliffe, 2020; Zhang et al., 2021). This technique is carried out to minimize bias due to using one of the methods or sources used (Fusch et al., 2018; Santos et al., 2020). Apart from that, it should be noted that in the triangulation technique in this research, not all of the data obtained is used, but only relevant data is used involving a classification process (data reduction)(Agustang, 2020; Giyarsih & Marfai, 2018; Hasanudin & Fitrianingsih, 2020; Tohir & Abidin, 2018).

First, the data obtained through interviews will be re-checked to determine whether there is a match between the first and second sample data. If there is conformity in the data provided by the first and second samples, either from the results of interviews or observations, it can be used to reinforce the research findings. Furthermore, a literature review will analyse physics concepts that are appropriate to the traditional *pletokan* game (from the researcher's point of view). The physics concepts in the traditional *pletokan* game are explored and analyzed in depth by looking for relevant and credible reference sources that reinforce the analysis. Thus, the data obtained through this kind of data triangulation model will be analyzed descriptively and qualitatively by involving three stages: data reduction, data presentation, and verification (data interference) (Fan et al., 2017; Nurlaily et al., 2019) so that the final data obtained is the result of exploring the final physics concepts in the *pletokan* game. After that, the advantages and disadvantages of related concepts regarding their relevance in

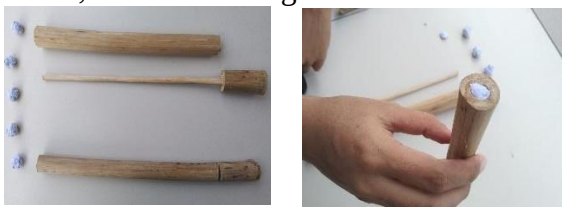
learning activities, especially in the Kurikulum Merdeka, are analysed. In this context, *pletokan* media is applied in physics learning, which acts as a fun physics learning media and a means to preserve existing local culture (Deta et al., 2021; Soko et al., 2019).

RESULTS AND DISCUSSION

This research is exploratory research and in-depth analysis of physics concepts in the traditional game *Pletokan*. This is because previous research only focused on using *pletokan* as a physics learning medium without an in-depth exploration of concepts and ethnomathematics studies. Thus, this research provides benefits to the world of education as one of the learning media innovations in the form of teaching aids based on local wisdom, traditional games rich in physics concepts in the Merdeka Belajar curriculum, as well as learning media and preserving existing local culture. Remember that physics learning is based only on solving problems by integrating equations. Thus, this kind of thing causes boredom, so innovation is needed by integrating traditional games as a physics learning media to create a learning atmosphere that is not monotonous. Based on literacy studies, observations and interviews that have been conducted on several discussion topics. Next, we present the results and discussion in the following systematics.

Pletokan Game Overview

The following is an overview of the traditional *pletokan* game made of old bamboo along with bullets made of papier-mâché, as shown in Figure 2 below.



(a) (b)

Figure 2. *Pletokan* with the Shot (a) and the Bullet in the Hole in the *Pletokan* Sheath (b)

Pletokan is a traditional game from bamboo (Abdulfattah & Putranta, 2020). The bamboo used is generally old bamboo because it has a higher level of resistance (does not break easily when played) compared to young bamboo (Sunimastuti, 2020). Old bamboo with a diameter of approximately 0.5 to 1 cm is cut along 25 cm, which functions as a shell bullet. Inside the bullet casing, there is a pounder (piercer) that is smaller in size than the diameter of the bullet casing. The smaller diameter of the plunger, when compared to the casing, aims to allow the plunger to enter the casing. In this type of game, please note that a sheath is provided at the end of the connector (which is held) to make it easier for the players to hold and play it. The following illustrates some of the *pletokan* components, as the information described previously is shown in Figure 3.

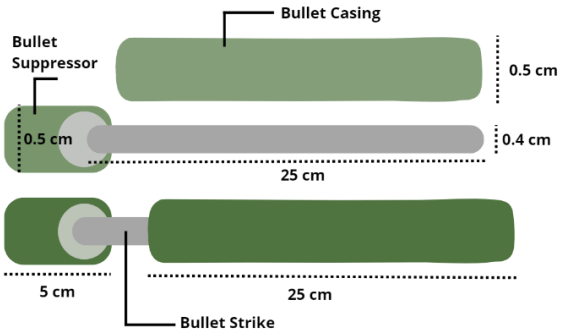


Figure 3. *Pletokan* Game Physics Design *Pletokan* Making Process

The following are the steps that are applied in the process of making *pletokan*:

1. Old bamboo with a length of 30 cm and a diameter of 0.5 cm to 1 cm is cut into two parts. The first part serves as a bullet casing with a length of 25 cm, and the second part functions as a gun grip (grip) with a length of 5 cm, as shown in Figure 3 above.
2. Bamboo that has been cut and then smoothed the surface using sandpaper. This is done to make it easier for the players to hold the instrument and maintain their safety so that there are no injuries to their hands when playing *Pletokan*.

3. The next stage is to cut a piece of bamboo to be used as the fill (poker) of the bullet casing by adjusting the size needed.
4. The next step is to ensure that the dent is not separated from the sheath of the handle. The stick handle can be glued together with the stick using the help of glue.
5. The last step is to prepare newsprint or other types of paper to be made into pulp. Next, the pulp is formed to resemble bullet balls. The choice of raw material for paper as a bullet is due to its softer texture, so if a bullet hits an opponent, it will not cause excessive injury or pain.

How to Play *Pletokan*

After the *pletokan* has been completed, then the *pletokan* is ready to be played. Playing *pletokan* is easy, as shown in Figure 4 below and described in the following steps.

(a) (b)

Figure 4. The *pletokan* is pulled (a) and then pushed (b) so that it will eject the bullet

The first stage carried out by players is to prepare *pletokan* as the main tool in this game. Next, the player prepares pulp, which will be formed into small balls as *pletokan* bullets. After the bullet is ready, the next step is to insert the bullet from the pulp that has been formed into the two holes of the bullet casing (both ends are filled with bullets from the pulp). When the bullets are ready to be placed in the two casing holes, the player simply inserts the pounder and then pushes it as fast as possible until the bullet inside comes out with a "*pletok*" sound. The following is an illustration of the *platoon* work system, as shown in Figure 5 below.

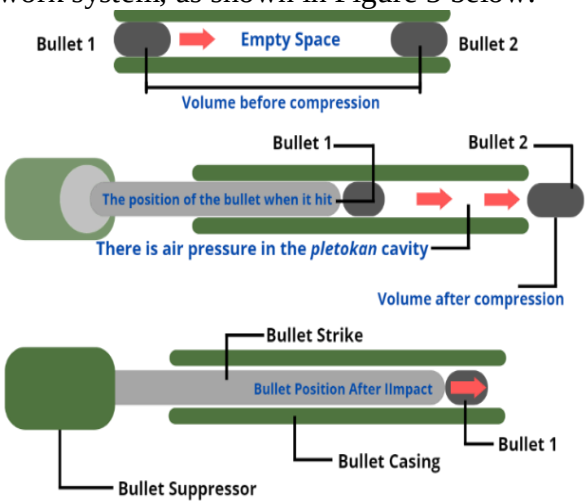


Figure 5. Illustration of the *Pletokan* Work System

Based on Figure 5 above, it shows the working system of *pletokan*. *Pletokan* starts to work when the bullet grower is pushed as fast as possible by the player's hand into the pletokan sheath. The collider will hit the first bullet, causing it to withdraw in volume. After that, the first bullet, which has decreased in volume, will be pushed to hit the second bullet, located at the end of the *pletokan* casing hole. When the first bullet hits the second bullet, the second bullet will be pushed out of the *pletokan* sheath and released by the first bullet. The exit state of these two bullets will cause an increase in the volume of the first bullet (the volume of the first bullet will return to its original state before being pushed by the grower), and the second bullet will be thrown a certain distance by forming a parabolic trajectory of motion.

Exploration Results of Physics Concepts

The following results from exploring the physics concepts in the *pletokan* game are presented in Table 1.

Table 1. Exploration Results of Physics Concepts in *Pletokan* Games

Physics Concepts	Activity	Description and Theory
Gravitational Potential Energy	Holding *Pletokan* while Playing	The *pletokan* game is played standing or in other positions against the earth's surface, like a policeman conducting surveillance of his target. This situation can be studied using the concept of potential energy. Potential energy depends on the object's position on the earth's surface (Abdullah, 2016). The greater the distance between the *pletokan* and the earth's surface, the greater the potential energy generated. The amount of potential energy pletokan possesses can be determined using the following equation. $$Ep = m\ g\ h \qquad (1)$$
Friction	Bullet Shift in the *Pletokan* Sheath	The frictional force in the *pletokan* game is created due to the good interaction between the two loaded bullets and between the attacker and the shell (Berman et al., 2018). When a bullet from a paper bullet is fired, there will be friction between the bullet casings, both from the first and second bullet. In addition, friction also occurs between the bullet grower and the casing. The amount of friction (kinetic) can be determined using the following equation. $$fk = \mu k \times N \qquad (2)$$ In addition, when the bamboo ripper is pushed so that it hits the bullet contained in the *pletokan* sheath, it will cause its volume to decrease. The force that causes the loss of volume is the friction force by the *pletokan* sheath. The magnitude of the frictional force can be determined using the following equation. $$f = -BA\frac{\Delta V}{V_0} \qquad (3)$$
Work and Energy	The thrust of the hand on the collider so that the bullet can be pushed forward	The work in the *pletokan* game is seen when the paper bullet moves out due to the thrust of the player's hand. The amount of work created in this *pletokan* game is largely determined by the force exerted by the player's hand (force is directly proportional to effort) (Abdullah, 2016). The amount of work created can be determined using the following equation. $$W = F \times S \qquad (4)$$
Ideal Gas Compression	Shot Hits the Bullet While Inside the *Pletokan* Sheath	When *pletokan* is played, gas compression occurs because the volume of gas in *pletokan* is reduced. So there is pressure inside. When the air volume decreases, the same number of air molecules remain in the tube but are forced to congregate in a smaller space. This kind of situation causes the gas pressure in the tube to increase. Therefore, gas compression in pletokan can be explained as applying the ideal gas law to a gas system that experiences changes in volume and pressure. The amount of gas compression can be determined using the equation in Boyle's Law (Chandan & Cascella, 2019). $$P_1 V_1 = P_2 V_2 \qquad (5)$$
Bulk Modulus	Throwing Bullets from the *Pletokan* Sheath (Bullit Velocity)	When the bullet (wet pulp) inside the *pletokan* sheath is pressed, volume will be reduced (because it contains Bulk modulus). The reduction in volume is similar to that of a spring when compressed (Brown et al., 2018; Guo et al., 2017). The magnitude of the Bulk modulus can be determined using the following equation. $$B = -\frac{f/A}{\Delta V/V_0} \qquad (6)$$
Sound Wave	The Throwing of Bullets from the *Pletokan* Sheath	The sound waves in this *pletokan* game are because when the bamboo gun is played, vibrations are generated in the sound of a pulp bullet being shot, producing sound waves. These sound waves propagate through the air and are heard as popping sounds. The high and low sound waves generated depend on the gas pressure in the *pletokan*. The greater the pressure, the louder the sound produced, and vice versa. The intensity of sound waves can be determined using the following equation (Abdullah, 2017). $$I = \frac{P}{4\pi R^2} \qquad (7)$$

Physics Concepts	Activity	Description and Theory
Dynamics of Motion	Throwing Bullets from the *Pletokan* Sheath (Bullit Velocity)	When leaving the bamboo tip, the compressive force is lost, and this state is similar to a spring that was initially compressed and suddenly released. As a result, the bullet will be ejected and return to its initial volume. Thus, the speed of throwing bullets can be determined using the following equation. $v = \frac{\pi}{2}(\sqrt{\frac{B}{\rho}})\frac{\Delta L}{L}$ (8)
Parabolic Motion	Bullet Shooting by *Pletokan*	When the bullet exits the *pletokan*, the bullet will make a parabolic motion (Meena & Sharma, 2022; Shtulman, 2017). Under these circumstances, the bullet experiences two kinds of motion on two different axes: the x-axis and the y-axis. On the x-axis, the bullet experiences GLB, and on the y-axis, the bullet experiences GLBB. The magnitude of the bullet velocity on each axis can be determined using the following equation. $V_{0x} = V_0 \cos\theta$ (9) Equation 9 above is the equation used to determine the bullet's velocity on the x-axis. The velocity of the bullet on the y-axis is as follows. $Vy = V_{0y} - gt$ (10)
Partially inelastic collision	Bullet Shooting by *Pletokan*	Bullets thrown out of the *pletokan* casing hit another object (opponent), and a partially inelastic collision will occur. This partially elastic collision causes the initial and final velocity of the bullet to be different, and some of the energy is converted into another form, which is sound energy. The magnitude of the coefficient of restitution at the time of this collision is 0.5, which can be determined using the following equation. $e = -\frac{vA' - vB'}{vA - vB}$ (11)

1. Gravitational Potential Energy

In the traditional *pletokan* game, the concept of gravitational potential energy is used, as shown in Figure 6 below.

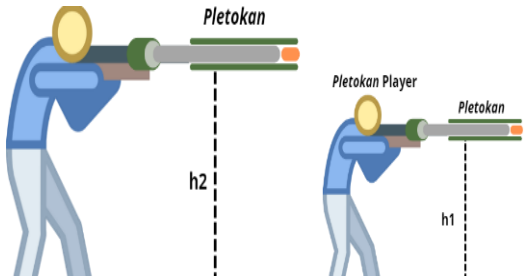


Figure 6. The Concept of Gravitational Potential Energy in the *Pletokan* Game

Figure 6 above shows that there are differences in height in the process of playing *pletokan*, which, of course, will have an impact on the size of the potential energy generated. Potential energy is the energy associated with a force that depends on the position or configuration of an object (or objects) relative to the environment (Serway & Jewett, 2018). The greater the height value of an object, the more potential energy it has will increase. The amount of potential energy can be determined using equation 1 as follows.

$$E_p = m \times g \times h$$

Information:
E_p : Potential Energy (Joule)
m : Mass (kg)
g : Acceleration of Gravity (m/s2)
h : Altitude (m)

In *pletokan* games, the concept of potential energy occurs when *pletokan* is to be played. In addition, at this stage, the *pletokan* player needs a lift force to create potential energy. The lifting force that the player does against the *pletokan* requires the strength of the muscle force from the player's hand. With this muscle force, players can change the position (change in height) of the *pletokan* against the earth's surface. The higher the player in lifting the *pletokan* against the earth's surface, the greater the required muscle force, which will cause an increase in the potential energy produced. The closer the pletokan's location to the

earth's surface, the muscle force needed to change the position of the *pletokan* is not too great so that the potential energy it has will be smaller.

2. Frictional Force

The following illustrates the concept of friction in the traditional *pletokan* game, as shown in Figure 7.

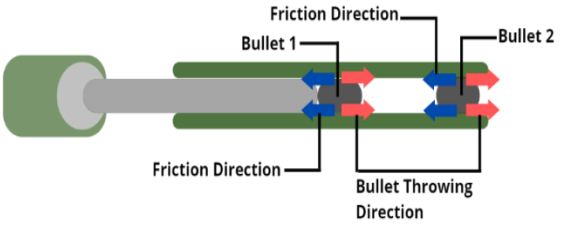


Figure 7. The concept of friction in *pletokan* games

Figure 7 above explains that in traditional *pletokan*, there is the concept of friction. The frictional force is an interaction between the surfaces of two or more objects whose direction of motion is resistant to the direction of the applied force (Emgin et al., 2018). When an object moves either on a surface or in a viscous media such as air or air, there is resistance to movement because the object interacts with its environment (Li et al., 2021; Newman, 2018; C. Yu et al., 2017). The frictional force in the *pletokan* game is kinetic friction, which is a force in the form of friction that occurs on objects with a tendency to move (friction between the first and second bullets as well as friction between the surface of the bullet and the sheath whose direction of motion is opposite to the direction of the applied force) (Sridharan et al., 2017). The magnitude of the frictional force experienced by the bullet and the *pletokan* casing cavity can be determined using gun two as follows.

$$fk = \mu k \text{ x } N$$

Information:
f_k : Kinetic Frictional Force (Newton)
μ_k : Coefficient of Kinetic Friction
N : Normal Force (Joule)

In addition, when the bamboo scoop is pushed to hit the bullet contained in the *pletokan* sheath, it will reduce the volume of the bullet derived from the pulp. The force that causes the loss of volume is the friction force by the *pletokan* sheath. The magnitude of the frictional force can be determined using equation 3 as follows.

$$f = -BA\frac{\Delta V}{V_0}$$

Information:
BA : Kinetic Friction (Newton)
ΔV : Volume Change (m3)
V_0 : Initial Volume (m3)

3. Work and Energy

The concept of work and energy in this game is illustrated in Figure 8.

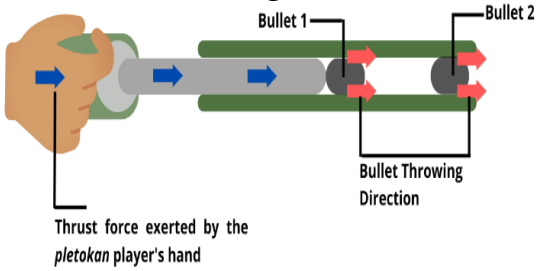


Figure 8. The concept of work and energy in *pletokan* games

The work in the *pletokan* game is seen when the paper bullet moves out due to the thrust of the player's hand. The amount of effort created in this *pletokan* game is largely determined by the force exerted by the *pletokan* player's hand. The greater the thrust exerted by the *pletokan* player's hands and the greater the distance traveled, the greater the effort created. This also applies vice versa; the smaller the thrust given and the distance travelled, the smaller the effort created. Thus, it can be said that the effort is directly proportional to the style and distance travelled. The amount of effort created can be determined using equation 4 (Abdullah, 2016).

$$W = F \text{ x } S$$

Information :
W : Work (Joule)
F : Force (Joule)
S : Distance (m)

4. Ideal Gas Compression

An ideal gas compression will occur when a pletokan bender pounds the bullet, as shown in Figure 9.

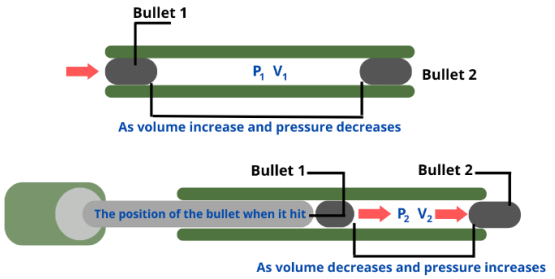


Figure 9. Gas Compression in *Pletokan* Game

Pletokan is a game that involves fast and strong gas pressure to produce a loud sound. The physics concepts associated with *pletokan* are gas compression and gas pressure. When the air in the *pletokan* tube is compressed by the user by pushing the handle inward, the volume of air in the tube will decrease (as shown in Figure 9 above). When the air volume decreases, the same number of air molecules remain in the tube but are forced to congregate in a smaller space. This causes the gas pressure in the tube to increase. When the clamp is released, the gas in the tube suddenly releases the accumulated pressure. The gas escapes quickly and forcefully, producing a loud sound like a "*pletok*". This process occurs because the gas tries to return to its original, more stable state and balances the pressure inside and outside the tube. In physics, a concept related to *pletokan* is the ideal gas law, which states that a gas's pressure, volume, and temperature are interrelated in a closed gas system. When a gas is compressed, the pressure increases because the volume decreases, and conversely, when the gas is expanded, the pressure decreases because the volume increases (Rimkus et al., 2018; Shanmugam et al., 2021). Therefore, *pletokan* can be explained as applying the ideal gas law to a gas system that changes volume and pressure. This concept can be solved using buying and selling five, which is Boyle's Law, buying and selling as follows (Lashin et al., 2018; Rodger, 2018).

$$P_1 V_1 = P_2 V_2$$

Information :
P_1 : Gas Pressure 1 (Pa)
P_2 : Gas Pressure 2 (Pa)
V_1 : Gas Volume 1 (m^3)
V_2 : Gas Volume 2 (m^3)

5. Bulk Modulus

A bullet made of wet pulp has a length of L when pushed with a shovel; the length decreases by ΔL and has a large velocity due to the pressure element in the *pletokan* sheath. The bullet is under pressure, so its volume will decrease. The magnitude of the volume change can be determined using the following equation.

$$\Delta V = A\Delta L \qquad (12)$$

ΔV : Volume change (m^3)
A : outside of the *Pletokan* casing cavity (m^2)
ΔL : change in length (m)

The volume reduction is due to the bulk modulus acting in it. However, when the bullet has been thrown out of the *pletokan* casing, it will return to its original size (volume), as shown in Figure 9 above. When the bullet has succeeded in getting out of the *pletokan* casing, the bullet will automatically get an elastic thrust due to changing the size of the bullet. Therefore, the magnitude of the bulk modulus can be determined using equation 6 as follows.

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

B : Bulk Modulus
ΔV : The change in volume of an object due to compression
V_0 : Initial volume before compression which is V0 = AL (m3)
f : Friction force by the wall of the *Pletokan* casing (N)
A : The cross-sectional area of the cavity wall of the *Pletokan* casing

6. Sound Waves

When we play *pletokan*, a sound is produced, which is heard as a "*pletokan*" in response to the process carried out when

playing the previous *pletokan*. The following illustrates the sound produced in *pletokan* games, as shown in Figure 10.

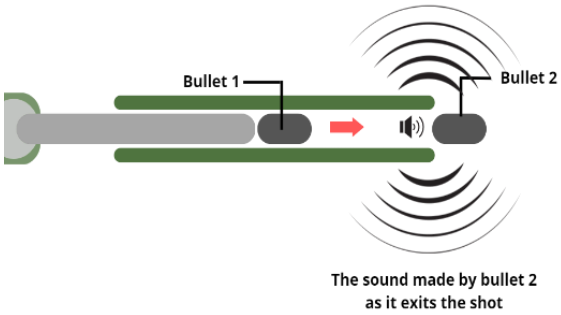


Figure 10. Sound Waves in *Pletokan* Game

Sound waves require a medium to propagate (Cheeke, 2017). In the *pletokan* game, the media used to propagate sound waves is the space inside the *pletokan* and the air around it. The sound waves in this *pletokan* game are because when the bamboo gun is played, vibrations are generated in the sound of a pulp bullet being shot, producing sound waves. The sound source is generated from stationary waves in *pletokan* or wind in *pletokan*. The high and low sound waves generated depend on the gas pressure in the *pletokan*. The greater the pressure, the louder the sound produced, and vice versa. The intensity of sound waves can be determined using equation 7 (Abdullah, 2017).

$$I = \frac{P}{4\pi R^2}$$

Information :

I : Sound Intensity (W/m^2)
P : Power (W)
R : Distance from a point to a sound source (m)

7. Dynamics of Motion

Thrown bullets will experience a change in speed. This change in velocity is evidenced when launching a bullet from the pletokan shroud to hitting another object (velocity always decreases, but it is not known for sure whether the velocity at point x is the same because other factors influence it, such as the wind factor). It should be noted that the thrown bullet has a velocity that is still affected by the Bulk Modulus as there is a change in the volume of the bullet. Thus, the magnitude of the bullet's velocity can be determined using equation 8 as follows.

$$v = \frac{\pi}{2}\left(\sqrt{\frac{B}{\rho}}\right)\frac{\Delta L}{L}$$

Information :

v : The initial velocity of the bullet when it leaves the end of the shot (m/s)
B : Bulk Modulus
ρ : Water Density (kg/m^3)
ΔL : Change in Length (m)
L : Length of bullet soaked in water (m)

8. Parabolic Motion

The parabolic motion in the *pletokan* game is very real when the fired bullet moves out of the *pletokan* casing. The following illustrates the concept of parabolic motion, as shown in Figure 11.

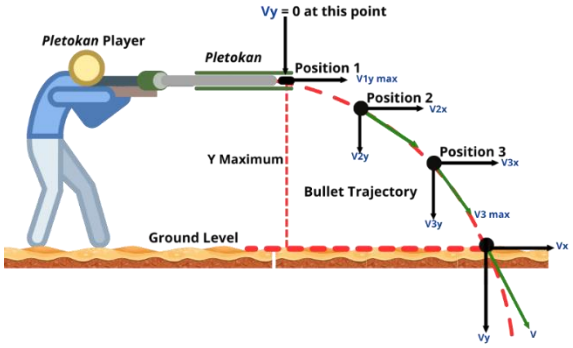


Figure 11. Concept of Parabolic Motion in *Pletokan* Game

Parabolic motion can be studied by analysis of its union vector (Ain et al., 2018). Vector analysis of the motion of the parabola on the pletokan is given in the figure above. The parabolic motion of the pletokan can be seen when the second bullet comes out of the pletokan as a result of the compressive force from inside the pletokan, which is considered when the bullet (pulp) is fired (Chirame et al., 2019). Thus, the trajectory resembles a parabola formed, as shown in Figure 11 above.

Based on Figure 11 above, the bullet experiences two types of motion. On the y-axis, the bullet experiences GLBB (uniform acceleration); on the x-axis, the bullet experiences GLB (uniform speed). These

two types of motion do not affect each other, but both only form a path resembling a parabola.

In this case, the bullet starts to be thrown at the top point position so that the highest value of the bullet position relative to the ground surface is known as the maximum Y. In addition, bullets thrown from the shot will experience GLBB, as evidenced by a decrease in velocity while on the y-axis trajectory. The magnitude of the bullet velocity on the y-axis can be determined using the following equation.

$$V_{0y} = V_0 \sin \theta \qquad (13)$$

Description:
V_{0y} : The initial velocity of the bullet on the y axis (m/s)
V_0 : Initial velocity of the bullet (m/s)
θ : Elevation angle (◦)

So, to determine the velocity of the bullet on the y-axis, you can use equation 10, as presented in Table 1 above. On the x-axis, the bullet will experience uniform, straight motion, which shows that the bullet's velocity on the x-axis is constant. The magnitude of the bullet velocity on the x-axis can be determined using the following equation.

$$V_x = V_0 \cos \theta \quad (14)$$

Description:
V_{0x} : Bullet velocity in the x-axis (m/s)
V0 : Initial velocity of the bullet (m/s)
θ : Elevation angle (◦)
g : Acceleration of gravity (m/s^2)

In this case, it should be noted that the V_{0x} value shown by Equation 9 in Table 1 is the same as V_x in Equation 14 above. In addition, in the study of parabola motion, the magnitude of the farthest throw distance when the bullet moves out of the *pletokan* casing can be determined. The magnitude of the value of the distance the bullet throws against the x-axis can be determined using weapon 15 as follows.

$$V_0 = V_x \qquad (15)$$

$$y = V_{0y}.t - \frac{1}{2}gt^2 \qquad (16)$$

Thus, the value of t can be determined using the following equation.

$$t^2 = \frac{2h}{g} \qquad (17)$$

$$t = \sqrt{\frac{2h}{g}} \qquad (18)$$

Thus, the maximum throwing distance of a bullet under these circumstances can be determined using the following equation.

$$x_{max} = V_0 . \sqrt{\frac{2h}{g}} \qquad (19)$$

Description:
V_{0x} : The initial velocity of the bullet in the x-axis (m/s)
V_{0y} : The initial velocity of the bullet in the y-axis (m/s)
y : Object's position on the y axis (m)
t : Time (s)
x_{max} : The maximum throw distance of the bullet on the x-axis (m)
h : Bullet maximum height (m)
g : Acceleration of gravity (m/s^2)

9. Partially Inelastic Collision

When the bullet is thrown out of the *pletokan* casing, it will hit the object in front of it. This kind of process contains the concept of glass called partially elastic collision. The following illustrates a partially elastic collision, as shown in Figure 12 below.

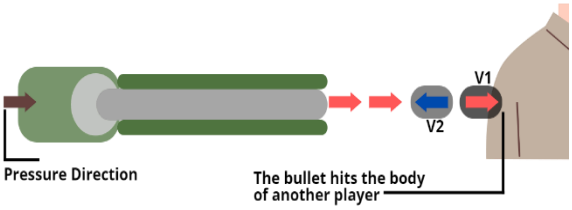


Figure 12. Partly Inelastic Collision in *Pletokan* Game

A partial loan collision is an impact event between two or more objects, which causes a change in kinetic energy (Astarita & Giofré, 2019; Dahnuss et al., 2021; Young-S & Adhikari, 2022). The bullet's kinetic energy before the collision is greater than the kinetic

energy after the collision (P. Yu et al., 2020). In the case of this collision, the law of conservation of energy no longer applies, but the law of conservation of momentum still applies. This type of collision has a coefficient of restitution of 0.5, which can be determined using equation 11 as follows.

$$e = -\frac{vA' - vB'}{vA - vB}$$

Information :
e : coefficient of restitution
vA' : the speed of object A after the collision (m/s)
vB' : the speed of object B after the collision (m/s)
vA : the speed of object A before the collision (m/s)
vB : The speed of object B before the collision (m/s)

After the bullet hits the body of another *pletokan* player, the bullet will bounce towards the direction of the *Pletokan* player (the player who threw the bullet himself). The following illustrates the occurrence of a partial loan collision when playing *pletokan*.

Potential Applications in Ethnophysics-based Physics Learning

In learning physics, physics concepts related to *pletokan* can be integrated with the learning achievement elements of the Kurikulum Merdeka shown in Table 2 below. Apart from making it easy for students to understand physics concepts in depth, this approach model can be used as a step in preserving Indonesian local culture. Based on the opinion (Khoiriyah & Suprapto, 2021; Putri et al., 2021; Rizki et al., 2023; Sholahuddin & Admoko, 2021; Suprapto et al., 2022) states that learning by integrating it through local culture makes it easier for students to understand the material being taught because the learning provided is contextual. In addition, learning physics, which is related to ethnoscience, has the advantage that students understand more about science itself when they apply it in everyday life and makes it easier for them to appreciate the richness of the nation's cultural treasures.

This *pletokan* game-based learning can be implemented into physics practical activities. One of these is parabolic motion, which is used to find several components, such as the maximum throwing distance of a bullet. Thus, this kind of learning activity can create a pleasant learning atmosphere, and students' understanding of concepts will be easier to improve.

Table 2. Basic Knowledge and Skills Competency in Physics with Exploration of Physics Concepts in Traditional *Pletokan* Games

Grade	Physics Concept	Basic Competency (Knowledge)	Basic Competency (Skills)
7 (Phase D)	Force and Motion	7.11 Investigate the effect of force on the motion that occurs around	At the end of grade 7, students can use various tools to make measurements and observations, paying attention to the relevant details of the observed object. Independently, students can ask further questions to clarify observations and make predictions about scientific investigations.
8 (Phase D)	Work and Energy	8.8 Investigate changes in energy forms that occur in various activities, such as photosynthesis and changes in potential energy into kinetic energy.	In answering questions at the end of grade 8, students can plan operational steps based on correct references. In investigations, students can use various types of variables to prove predictions, present data in the form of tables, graphs, and

Grade	Physics Concept	Basic Competency (Knowledge)	Basic Competency (Skills)
			models as well as explain observations and patterns or relationships in digital or non-digital data, collect data from their investigations, use secondary data and use scientific understanding to identify relationships and draw conclusions based on scientific evidence.
9 (Phase D)	Pressure	9.5 Investigate the principle of liquid pressure at a certain depth, applying Pascal's law, buoyancy, and capillarity to occurring phenomena.	At the end of grade 9, students were evaluated by comparing their knowledge with existing theories. Shows the advantages and disadvantages of the inquiry process and its effect on the data. Presents problems in the methodology. Communicating the results of the investigation as a whole supported by arguments, language and scientific conventions that are appropriate to the context of the investigation. Expressing patterns of systematic thinking according to the specified format.
9 (Phase D)	Sound and Waves	9.6 Investigate the relationship between vibrations, waves and sound through a simple experiment by searching for information about the radar system and putting it as a poster.	
11 (Phase F)	Newton's Law (I, II, and III)	11.2 Analyze the concept of the kinematics of rectilinear motion and identify the characteristics of objects moving in a straight line with constant speed constant acceleration through investigations, collect data, analyze and present the research results in various representations such as tables or graphs and communicate them	
11 (Phase F)	Parabolic Motion	11.3 Describe vector concepts and make observations to analyze straight two-dimensional motion (parabolic motion) and communicate it in spoken or written form	
11 (Phase F)	Newton's Law (II)	11.4 Analyzing the relationship between force, mass and acceleration in the concept of dynamics of motion and its application to solve problems in everyday life	
11 (Phase F)	Momentum and Impulse	11.5 apply the concepts of impulse, momentum and the law of conservation of momentum in everyday events and experiment with the application of the law of conservation of momentum, such as a falling ball or simple rocket, analyze the experimental results and present them	
11 (Phase F)	Sound and Waves	11.15 Analyze the concept of sound waves, sound wave intensity, wave intensity quadrants and the Doppler effect through investigation using the available tools, analyze the investigation results and present them.	

CONCLUSION AND SUGGESTION

Based on the data and analysis that has been carried out, it can be concluded that the traditional *pletokan* game can be integrated into the Merdeka Belajar curriculum. This is because traditional game-based physics learning can create a contextual learning environment (one of the goals of the Merdeka Belajar curriculum itself is to create contextual learning) to increase student motivation and learning outcomes. Apart from that, in this research, we obtained physics concepts that have been explored and analyzed in depth in the traditional game of

pletokan, including gravitational potential energy, friction force, work and energy, ideal gas compression, mass modulus, sound waves, motion dynamics, parabolic motion, and partially elastic collisions. The results of this research show that there is potential in the traditional *pletokan* game as a physics learning media based on local Indonesian wisdom.

Ethnoscience-based physics learning provides benefits in learning to understand the material more easily, increase students' learning motivation, improve learning outcomes, and participate in efforts to preserve national culture. This research is new. It is an in-depth exploration of physics concepts in the traditional game of *pletokan* as a learning medium in the Merdeka Belajar curriculum, where research of this kind was previously limited. However, this research has limitations. The number of samples used is limited, documentation for the second sample was not recorded properly, and journal references regarding the *pletokan* game are very limited. Future researchers should study the physics concepts in the traditional *pletokan* game in more depth, look for more references to strengthen the data analysis and carry out documentation activities at each research stage. Apart from that, researchers also suggest exploring physics concepts in other types of traditional games to enrich new findings in the world of research and expand efforts to preserve the nation's local culture.

REFERENCES

Abdulfattah, A., & Putranta, H. (2020). The development of mobile learning assisted local culture-based subject-specific pedagogy in realizing the learning outcomes of physics subject. *International Conference on Educational Research and Innovation (ICERI 2019)*, 71–78.

Abdullah, M. (2016). Besaran-Besaran Gerak. *Fisika Dasar 1*, 81–159.

Abdullah, M. (2017). Basic Physics. In *Institut Teknologi Bandung*. https://doi.org/10.4324/9780429279034-1

Agustang, A. (2020). Symbolic violence towards students in the context of the existence of the stereotypical frames of lecturers and students in the higher education system in Indonesia. *PalArch's Journal of Archaeology of Egypt/Egyptology*, *17*(2), 249–258.

Ain, T. N., Wibowo, H. A. C., Rohman, A., & Deta, U. A. (2018). The scientific argumentation profile of physics teacher candidate in Surabaya. *Journal of Physics: Conference Series*, *997*(1), 12025.

Aisyah, E. N. (2017). Character building in early childhood through traditional games. *3rd International Conference on Education and Training (ICET 2017)*, 292–294.

Alam, A. (2022). A digital game based learning approach for effective curriculum transaction for teaching-learning of artificial intelligence and machine learning. *2022 International Conference on Sustainable Computing and Data Communication Systems (ICSCDS)*, 69–74.

Alfalah, S. F. M. (2018). Perceptions toward adopting virtual reality as a teaching aid in information technology. *Education and Information Technologies*, *23*, 2633–2653.

Ali, M., & Aqobah, Q. J. (2021). Permainan Tradisional Betawi Untuk Mengembangkan Keterampilan Sosial Anak. *Jurnal Eksistensi Pendidikan Luar Sekolah (E-Plus)*, *6*(2).

Almeida, F. (2018). Strategies to perform a mixed methods study. *European Journal of Education Studies*.

Anggita, G. M. (2018). Eksistensi permainan tradisional sebagai warisan budaya bangsa. *JOSSAE (Journal of Sport Science and Education)*, *3*(2), 55–59.

Anthony, L. B. (2017). The integration of Ethno Physics into school curriculum for skill acquisition among secondary school students in Nigeria. *International*

Journal of Innovative Research and Advanced Studies (IJIRAS), *4*(8), 62–65.

Anwar, A., Suardika, I. K., Mursidin T, M. T., Suleiman, A. R., & Syukur, M. (2018). Kalosara Revitalization as an Ethno-Pedagogical Media in the Development of Character of Junior High School Students. *International Education Studie*, *11*(1), 172–183.

Astarita, V., & Giofré, V. P. (2019). From traffic conflict simulation to traffic crash simulation: Introducing traffic safety indicators based on the explicit simulation of potential driver errors. *Simulation Modelling Practice and Theory*, *94*, 215–236.

Balletti, C., Ballarin, M., & Guerra, F. (2017). 3D printing: State of the art and future perspectives. *Journal of Cultural Heritage*, *26*, 172–182.

Baran, M., Maskan, A., & Yasar, S. (2018). Learning Physics through Project-Based Learning Game Techniques. *International Journal of Instruction*, *11*(2), 221–234.

Berman, D., Erdemir, A., & Sumant, A. V. (2018). Approaches for achieving superlubricity in two-dimensional materials. *ACS Nano*, *12*(3), 2122–2137.

Brown, J. A., Carroll, J. D., Huddleston, B., Casias, Z., & Long, K. N. (2018). A multiscale study of damage in elastomeric syntactic foams. *Journal of Materials Science*, *53*(14), 10479–10498.

Cahyono, T. (2022). Management of Guidance and Counseling Services in The Merdeka Belajar curriculum. *Bisma The Journal of Counseling*, *6*(2).

Calabrò, A., Vecchiarini, M., Gast, J., Campopiano, G., De Massis, A., & Kraus, S. (2019). Innovation in family firms: A systematic literature review and guidance for future research. *International Journal of Management Reviews*, *21*(3), 317–355.

Campbell, S., Greenwood, M., Prior, S., Shearer, T., Walkem, K., Young, S., Bywaters, D., & Walker, K. (2020). Purposive sampling: complex or simple? Research case examples. *Journal of Research in Nursing*, *25*(8), 652–661.

Chandan, G., & Cascella, M. (2019). *Gas laws and clinical application.*

Cheeke, J. D. N. (2017). *Fundamentals and applications of ultrasonic waves*. CRC press.

Chen, P.-Y., Hwang, G.-J., Yeh, S.-Y., Chen, Y.-T., Chen, T.-W., & Chien, C.-H. (2021). Three decades of game-based learning in science and mathematics education: an integrated bibliometric analysis and systematic review. *Journal of Computers in Education*, 1–22.

Chirame, N. A., Sarsar, R. B., & Naik, S. D. (2019). Effect of Igniter Design on Differential Pressure. *2019 International Conference on Range Technology (ICORT)*, 1–5.

Cooper, H., Hedges, L. V, & Valentine, J. C. (2019). *The handbook of research synthesis and meta-analysis*. Russell Sage Foundation.

Dahnuss, D., Marwoto, P., Iswari, R. S., & Listiaji, P. (2021). Marbles and smartphone on physics laboratory: an investigation for finding coefficient of restitution. *Journal of Physics: Conference Series*, *1918*(2), 22005.

Deta, U. A., Kurniawan, F. K., Lestari, N. A., Yantidewi, M., Jauhariyah, M. N. R., & Prahani, B. K. (2021). Literature review on the use of educational physics games in improving learning outcomes. *Journal of Physics: Conference Series*, *1805*(1), 12038.

Dewi, E. R., & Alam, A. A. (2020). Transformation Model for Character Education of Student. *Cypriot Journal of Educational Sciences*, *15*(5), 1228–1237.

Dixon, M. J., Larche, C. J., Stange, M., Graydon, C., & Fugelsang, J. A. (2018). Near-misses and stop buttons in slot machine play: An investigation of how

they affect players, and may foster erroneous cognitions. *Journal of Gambling Studies*, *34*, 161–180.

Dwijayani, N. M. (2019). Development of circle learning media to improve student learning outcomes. *Journal of Physics: Conference Series*, *1321*(2), 22099.

Emgin, S. E., Aghakhani, A., Sezgin, T. M., & Basdogan, C. (2018). Haptable: An interactive tabletop providing online haptic feedback for touch gestures. *IEEE Transactions on Visualization and Computer Graphics*, *25*(9), 2749–2762.

Errandonea, I., Beltrán, S., & Arrizabalaga, S. (2020). Digital Twin for maintenance: A literature review. *Computers in Industry*, *123*, 103316.

Eskasasnanda, I. D. P. (2017). Causes and effects of online video game playing among junior-senior high school students in Malang East Java. *Komunitas*, *9*(2), 191–202.

Etikan, I., & Bala, K. (2017). Sampling and sampling methods. *Biometrics & Biostatistics International Journal*, *5*(6), 149.

Fan, Z., Weng, Y., Chen, G., & Liao, H. (2017). 3D interactive surgical visualization system using mobile spatial information acquisition and autostereoscopic display. *Journal of Biomedical Informatics*, *71*, 154–164.

Farquhar, J., Michels, N., & Robson, J. (2020). Triangulation in industrial qualitative case study research: Widening the scope. *Industrial Marketing Management*, *87*, 160–170.

Fatmawati, E. (2021). Strategies to grow a proud attitude towards Indonesian cultural diversity. *Linguistics and Culture Review*, *5*(S1), 810–820.

Febrianto, P. T., Mas'udah, S., & Megasari, L. A. (2020). Implementation of online learning during the covid-19 pandemic on Madura Island, Indonesia. *International Journal of Learning, Teaching and Educational Research*, *19*(8), 233–254.

Fitri, M., Nur, H. A., & Putri, W. (2020). The commemoration of independence day: recalling Indonesian traditional games. *Frontiers in Psychology*, *11*, 587196.

Fusch, P., Fusch, G. E., & Ness, L. R. (2018). Denzin's paradigm shift: Revisiting triangulation in qualitative research. *Journal of Sustainable Social Change*, *10*(1), 2.

Garousi, V., Felderer, M., & Mäntylä, M. V. (2019). Guidelines for including grey literature and conducting multivocal literature reviews in software engineering. *Information and Software Technology*, *106*, 101–121.

Giyarsih, S. R., & Marfai, M. A. (2018). The perception of stakeholders on regional transformation on the outskirts of Yogyakarta City, Indonesia. *Geojournal*, *83*(5), 983–991.

Gomme, A. B. (2020). *The Traditional Games of England, Scotland, and Ireland: Volume 2*. BoD–Books on Demand.

Guo, M., Pegoraro, A. F., Mao, A., Zhou, E. H., Arany, P. R., Han, Y., Burnette, D. T., Jensen, M. H., Kasza, K. E., & Moore, J. R. (2017). Cell volume change through water efflux impacts cell stiffness and stem cell fate. *Proceedings of the National Academy of Sciences*, *114*(41), E8618–E8627.

Hadi, A., Marniati, M., Ngindana, R., Kurdi, M. S., Kurdi, M. S., & Fauziah, F. (2023). New Paradigm of Merdeka Belajar curriculum in Schools. *AL-ISHLAH: Jurnal Pendidikan*, *15*(2), 1497–1510.

Hadjarati, H., Dai, A., & Haryanto, A. I. (2021). Permainan Tradisional Daerah Bolaang Mongondow Selatan. *Jurnal Ilmu Keolahragaan Undiksha*, *9*(1), 46–54.

Hamilton, D., McKechnie, J., Edgerton, E., & Wilson, C. (2021). Immersive virtual reality as a pedagogical tool in education: a systematic literature review of quantitative learning outcomes and experimental design. *Journal of Computers in Education*, *8*(1), 1–32.

Hasanudin, C., & Fitrianingsih, A. (2020). Verbal Linguistic Intelligence of the First-Year Students of Indonesian Education Program: A Case in Reading Subject. *European Journal of Educational Research*, *9*(1), 117–128.

Intani, R. (2021). Membangun Pendidikan Karakter dengan Berkesenian. *JPKS (Jurnal Pendidikan dan Kajian Seni)*, *6*(2).

Irawati, D., Najili, H., Supiana, S., & Zaqiah, Q. Y. (2022). Merdeka Belajar curriculum Innovation and Its Application in Education Units. *Edumaspul: Jurnal Pendidikan*, *6*(2), 2506–2514.

Khoiriyah, S., & Suprapto, N. (2021). Effectiveness of comics to train students' critical thinking skills in physics learning: A mini-review. *Studies in Learning and Teaching*, *2*(1), 5–15.

Klar, S., & Leeper, T. J. (2019). Identities and intersectionality: a case for Purposive sampling in Survey-Experimental research. *Experimental Methods in Survey Research: Techniques That Combine Random Sampling with Random Assignment*, 419–433.

Komariah, I., & Salim, T. A. (2019). Kampoeng Hompimpa: Preserving Traditional Games Amidst the Barrage of Online Games. *UI Proceedings on Social Science and Humanities*, *3*(1).

Kurniawan, D. A., Kiska, N. D., & Damayanti, L. (2022). Teaching Primary School Students through Local Cultural Games for Improving Positive Characters. *International Journal of Instruction*, *15*(3), 1047–1078.

Lai, N. K., Ang, T. F., Por, L. Y., & Liew, C. S. (2018). The impact of play on child development-a literature review. *European Early Childhood Education Research Journal*, *26*(5), 625–643.

Laila, A., Budiningsih, C. A., & Syamsi, K. (2021). Textbooks Based on Local Wisdom to Improve Reading and Writing Skills of Elementary School Students. *International Journal of Evaluation and Research in Education*, *10*(3), 886–892.

Lashin, A., AlQuraishi, A. A., AlKhidir, K., Kinawy, M. M., & Al Jawder, A. (2018). Characterization of the Permo-Triassic upper Khuff reservoir, central Saudi Arabia: An integrated core plugs, petro-fabrics and mercury injection analysis. *Journal of African Earth Sciences*, *145*, 284–296.

Lathifah, M. F., Hidayati, B. N., & Zulandri. (2019). Pengintegrasian Potensi Lokal Pada Mata Kuliah Pendidikan Karakter Untuk Meningkatkan Hasil Belajar Dan Rasa Hormat Mahasiswa Terhadap Lingkungan. *JUPE : Jurnal Pendidikan Mandala*, *4*(4), 0–5. https://doi.org/10.36312/jupe.v4i4.995

Laurens, T., Batlolona, F. A., Batlolona, J. R., & Leasa, M. (2017). How does realistic mathematics education (RME) improve students' mathematics cognitive achievement? *Eurasia Journal of Mathematics, Science and Technology Education*, *14*(2), 569–578.

Lawrence, J. E., & Tar, U. A. (2018). Factors that influence teachers' adoption and integration of ICT in teaching/learning process. *Educational Media International*, *55*(1), 79–105.

Li, G., Lauga, E., & Ardekani, A. M. (2021). Microswimming in viscoelastic fluids. *Journal of Non-Newtonian Fluid Mechanics*, *297*, 104655.

Lin, C.-J., Hwang, G.-J., Fu, Q.-K., & Chen, J.-F. (2018). A flipped contextual game-based learning approach to enhancing EFL students' English business writing performance and reflective behaviors. *Journal of Educational Technology & Society*, *21*(3), 117–131.

Liu, J., Bai, D., & Chen, L. (2018). 3-D point cloud registration algorithm based on greedy projection triangulation. *Applied Sciences*, *8*(10), 1776.

Ma'arif, N. N. (2021). Meningkatkan Kemampuan Fisik Motorik Kasar Anak

melalui Permainan Tradisional *Pletokan* pada Kelompok B TKM NU 169 Khubbul Wathon Cerme Gresik. *Atthiflah: Journal of Early Childhood Islamic Education*, *8*(2), 111–120.

Maipita, I., Dalimunthe, M. B., & Sagala, G. H. (2020). *The development structure of the Merdeka Belajar curriculum in the industrial revolution era*.

Mairizwan, M., Hidayati, H., Dewi, W. S., Afrizon, R., & Jarlis, R. (2022). Increasing the Competence of Physics Teachers in Designing PjBL-Based Teaching Aids for the Implementation of the Merdeka Curriculum. *Jurnal Penelitian Pendidikan IPA*, *8*(6), 2948–2953.

Marlina, S., & Pransiska, R. (2017). The Effectiveness of Traditional Games on the Development of Social Ability of Children in Kindergarten of Baiturridha Padang Pariaman. *International Conference of Early Childhood Education (ICECE 2017)*, 220–223.

Meena, K. P., & Sharma, S. (2022). Applications of Projectile Motion in Real Life and Technological Advancements. *Central Asian Journal of Theoretical and Applied Science*, *3*(11), 226–236.

Molina, A. I., Navarro, Ó., Ortega, M., & Lacruz, M. (2018). Evaluating multimedia learning materials in primary education using eye tracking. *Computer Standards & Interfaces*, *59*, 45–60.

Moore, R. C. (2017). *Childhood's domain: Play and place in child development* (Vol. 6). Routledge.

Newman, J. N. (2018). *Marine hydrodynamics*. The MIT press.

Nielsen, B. B., Welch, C., Chidlow, A., Miller, S. R., Aguzzoli, R., Gardner, E., Karafyllia, M., & Pegoraro, D. (2020). Fifty years of methodological trends in JIBS: Why future IB research needs more triangulation. *Journal of International Business Studies*, *51*(9), 1478–1499.

Novia, K., Mawardi, M., & Suryani, O. (2023). Development of Teaching Materials to Support Merdeka Curriculum Learning on Solubility and Solubility Product in F Phase. *Jurnal Penelitian Pendidikan IPA*, *9*(7), 5481–5491.

Nurlaily, V. A., Soegiyanto, H., & Usodo, B. (2019). Elementary School Teachers' Obstacles in the Implementation of Problem-Based Learning Model in Mathematics Learning. *Journal on Mathematics Education*, *10*(2), 229–238.

O'Donovan, R., & McAuliffe, E. (2020). Exploring psychological safety in healthcare teams to inform the development of interventions: combining observational, survey and interview data. *BMC Health Services Research*, *20*, 1–16.

Pertiwi, A. K., & Pusparini, R. (2021). Vocational High School English Teachers' Perspectives On "Merdeka Belajar" Curriculum. *Edukatif: Jurnal Ilmu Pendidikan*, *3*(5), 1982–1992.

Pratama, G. S., & Retnawati, H. (2018). Urgency of higher order thinking skills (HOTS) content analysis in mathematics textbook. *Journal of Physics: Conference Series*, *1097*(1), 12147.

Pratiwi, A. B. (2020). Permainan tradisional engrang dari Provinsi Banten dan pembentukan karakter menghargai prestasi peserta didik MI/SD di Indonesia. *Madrosatuna: Jurnal Pendidikan Guru Madrasah Ibtidaiyah*, *3*(1), 13–28.

Puspitarini, Y. D., & Hanif, M. (2019). Using Learning Media to Increase Learning Motivation in Elementary School. *Anatolian Journal of Education*, *4*(2), 53–60.

Putri, M. A. N., Rohmah, A. A., Andriani, A. P., Suprapto, N., & Admoko, S. (2021). Development of Physics Comic'History of Physics Series: The Development of Atom'. *Berkala Ilmiah Pendidikan*

Fisika, *9*(3), 298–305.

Queirós, A., Faria, D., & Almeida, F. (2017). Strengths and limitations of qualitative and quantitative research methods. *European Journal of Education Studies*.

Rahmatullah, A. S., & Ghufron, S. (2021). The Effectiveness Of'facebook'as Indonesian Language Learning Media For Elementary School Student: Distance Learning Solutions In The Era Of The Covid-19 Pandemic. *Multicultural Education*, *7*(04), 27–37.

Rapanta, C., Botturi, L., Goodyear, P., Guàrdia, L., & Koole, M. (2020). Online university teaching during and after the Covid-19 crisis: Refocusing teacher presence and learning activity. *Postdigital Science and Education*, *2*, 923–945.

REGIANA, E. (2018). *Game Permainan Tradisional sebagai Media Pelestarian Budaya Indonesia*. Unika Soegijapranata Semarang.

Rimkus, A., Matijošius, J., Bogdevičius, M., Bereczky, Á., & Török, Á. (2018). An investigation of the efficiency of using O2 and H2 (hydrooxile gas-HHO) gas additives in a ci engine operating on diesel fuel and biodiesel. *Energy*, *152*, 640–651.

Rindaningsih, I., Arifin, B. U. B., & Mustaqim, I. (2023). Empowering Teachers in Indonesia: A Framework for Project-Based Flipped Learning and Merdeka Belajar. *International Conference on Intellectuals' Global Responsibility (ICIGR 2022)*, 177–184.

Rizki, I. A., Saphira, H. V., Alfarizy, Y., Saputri, A. D., Ramadani, R., & Suprapto, N. (2023). Adventuring Physics: Integration of Adventure Game and Augmented Reality Based on Android in Physics Learning. *International Journal of Interactive Mobile Technologies*, *17*(1).

Rizki, I. A., Suprapto, N., & Admoko, S. (2022). Exploration of physics concepts with traditional engklek (hopscotch) game: Is it potential in physics ethno-STEM learning? *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, *11*(1), 19–33.

Roberts, R. E. (2020). Qualitative Interview Questions: Guidance for Novice Researchers. *Qualitative Report*, *25*(9).

Rodger, J. A. (2018). Advances in multisensor information fusion: A Markov–Kalman viscosity fuzzy statistical predictor for analysis of oxygen flow, diffusion, speed, temperature, and time metrics in CPAP. *Expert Systems*, *35*(4), e12270.

Santos, K. da S., Ribeiro, M. C., Queiroga, D. E. U. de, Silva, I. A. P. da, & Ferreira, S. M. S. (2020). The use of multiple triangulations as a validation strategy in a qualitative study. *Ciencia & Saude Coletiva*, *25*, 655–664.

Saphira, H. V., Admoko, S., & Suprapto, N. (2022). Ogoh-ogoh: An indonesian creative local wisdom inspired by hindu philosophy as ethno-physics. *Vidyottama Sanatana: International Journal of Hindu Science and Religious Studies*, *6*(1), 23–33.

Satiti, A. D. R., & Falikhatun, F. (2022). Accounting Curriculum Evaluation in Implementation Merdeka Belajar-Kampus Merdeka. *Assets: Jurnal Akuntansi Dan Pendidikan*, *11*(1), 21–35.

Selwyn, N., Hillman, T., Eynon, R., Ferreira, G., Knox, J., Macgilchrist, F., & Sancho-Gil, J. M. (2020). What's next for Ed-Tech? Critical hopes and concerns for the 2020s. In *Learning, Media and Technology* (Vol. 45, Issue 1, pp. 1–6). Taylor & Francis.

Serway, R. A., & Jewett, J. W. (2018). *Physics for scientists and engineers*. Cengage learning.

Shadiev, R., Hwang, W.-Y., & Huang, Y.-M. (2017). Review of research on mobile language learning in authentic environments. *Computer Assisted Language Learning*, *30*(3–4), 284–303.

Shanmugam, R., Dillikannan, D., Kaliyaperumal, G., De Poures, M. V., &

Babu, R. K. (2021). A comprehensive study on the effects of 1-decanol, compression ratio and exhaust gas recirculation on diesel engine characteristics powered with low density polyethylene oil. *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, *43*(23), 3064–3081.

Sholahuddin, M. I., & Admoko, S. (2021). Exploration of physics concepts based on local wisdom kolecer traditional games. *PENDIPA Journal of Science Education*, *5*(1), 70–78.

Shtulman, A. (2017). *Scienceblind: Why our intuitive theories about the world are so often wrong*. Hachette UK.

Sihombing, A. A., Anugrahsari, S., Parlina, N., & Kusumastuti, Y. S. (2021). " Merdeka Belajar" in an Online Learning during the COVID-19 Outbreak: Concept and Implementation. *Asian Journal of University Education*, *17*(4), 35–45.

Silaban, A. A. H., & Bhaskaraa, G. I. (2020). Tingkat Partisipasi Masyarakat Lokal dalam Pengembangan Kampung Wisata Kreatif Dago Pojok di Kota Bandung. *Jurnal Destinasi Pariwisata*, *8*(1), 74–81.

Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. *Journal of Business Research*, *104*, 333–339.

Sobaih, A. E. E., Hasanein, A. M., & Abu Elnasr, A. E. (2020). Responses to COVID-19 in higher education: Social media usage for sustaining formal academic communication in developing countries. *Sustainability*, *12*(16), 6520.

Soko, I. P., Setiawan, A., & Widodo, A. (2019). Physics teachers' ability in planning and implementing cultural-based physics learning activities on education and training. *Jurnal Penelitian Dan Pembelajaran IPA*, *5*(2), 169–184.

Solikhah, P. I., & Purnomo, P. (2022). The Opportunity and Challenges of Implementing a Prototype Curriculum. *Nazhruna: Jurnal Pendidikan Islam*, *5*(2), 407–421.

Sridharan, K., Sandbhor, S., Rajasekaran, U. B., Sam, G., Ramees, M. M., & Abraham, E. A. (2017). An in vitro evaluation of friction characteristics of conventional stainless steel and self-ligating stainless steel brackets with different dimensions of archwires in various bracket-archwire combination. *J Contemp Dent Pract*, *18*(8), 660–664.

Suastra, I. W., & Pujani, N. M. (2021). Local wisdom in Lombok island with the potential of ethnoscience for the development of learning models in junior high school. *Journal of Physics: Conference Series*, *1816*(1), 12105.

Sukaesih, S., Nurislaminingsih, R., & Winoto, Y. (2022). Mapping of Betawi indigenous knowledge in collections at the Setu Babakan Museum. *Linguistics and Culture Review*, *6*(S2), 368–382.

Sulistyaningtyas, R. E., & Fauziah, P. Y. (2019). The implementation of traditional games for early childhood education. *3rd International Conference on Current Issues in Education (ICCIE 2018)*, 431–435.

Sunimastuti, W. (2020). *Perancangan Infografis Macam Permainan Tradisional Anak di Indonesia*.

Suprapto, N., Suliyanah, S., Deta, U. A., & Sya'roni, I. (2022). Glocalization of Bull Racing: A Program for Preservation Kerapan Sapi as Madurese Local Wisdom. *Kawalu: Journal of Local Culture*, *9*(1), 35–52.

Supriani, Y., Supriyadi, A., Arifin, B. S., & Ruswandi, U. (2022). Islamic Education In The Merdeka Belajar curriculum. *Edumaspul: Jurnal Pendidikan*, *6*(2), 2780–2787.

Susanto, H. (2017). Perception on Cultural Diversity and Multiculturalism Education. *1st International Conference on Social Sciences Education-" Multicultural Transformation in Education, Social Sciences and Wetland*

Environment"(ICSSE 2017), 125–129.

Thalib, S. B., & Ahmad, M. A. (2020). The Outdoor Learning Modules Based on Traditional Games in Improving Prosocial Behaviour of Early Childhood. *International Education Studies*, *13*(10), 88–104.

Tohir, M., & Abidin, Z. (2018). Students creative thinking skills in solving two dimensional arithmetic series through research-based learning. *Journal of Physics: Conference Series*, *1008*(1), 12072.

Trajkovik, V., Malinovski, T., Vasileva-Stojanovska, T., & Vasileva, M. (2018). Traditional games in elementary school: Relationships of student's personality traits, motivation and experience with learning outcomes. *PloS One*, *13*(8), e0202172.

Wahyuni, M., Syamsi, I., & Haryanto, I. (2019). Character values contained on traditional games of hide and seek in inclusion school. *International Conference on Special and Inclusive Education (ICSIE 2018)*, 173–175.

Wang, Y., McKee, M., Torbica, A., & Stuckler, D. (2019). Systematic literature review on the spread of health-related misinformation on social media. *Social Science & Medicine*, *240*, 112552.

Warmansyah, J., Zulhendri, Z., & Amalina, A. (2021). The Effectiveness of Lore Traditional Games Towards The Ability to Recognize The Concept of Numbers on Early Childhood. *Ta'dib*, *24*(2), 261–268.

Widiana, I. W., nyoman Jampel, I., & Prawini, I. G. A. P. (2018). The effectiveness of communication learning activities based on tradisional game toward the cognitive process dimension. *Cakrawala Pendidikan*, *2*, 260396.

Widodo, S. A. (2018). Selection of Learning Media Mathematics for Junior School Students. *Turkish Online Journal of Educational Technology-TOJET*, *17*(1), 154–160.

Windschitl, M., Thompson, J., & Braaten, M. (2020). *Ambitious science teaching*. Harvard Education Press.

Wulansari, N. I., & Admoko, S. (2021). Eksplorasi konsep fisika pada tari dhadak merak reog ponorogo. *PENDIPA Journal of Science Education*, *5*(2), 163–172.

Yang, Y., Shafi, M., Song, X., & Yang, R. (2018). Preservation of cultural heritage embodied in traditional crafts in the developing countries. A case study of Pakistani handicraft industry. *Sustainability*, *10*(5), 1336.

Young-S, L. E., & Adhikari, S. K. (2022). Deep inelastic collision of two-dimensional anisotropic dipolar condensate solitons. *Communications in Nonlinear Science and Numerical Simulation*, *106*, 106094.

Yu, C., Zhu, X., Li, K., Cao, M., & Jiang, L. (2017). Manipulating Bubbles in Aqueous Environment via a Lubricant-Infused Slippery Surface. *Advanced Functional Materials*, *27*(29), 1701605.

Yu, P., Chen, G., Peng, X., Zhang, Y., & Zhang, H. (2020). Exploring inelastic collisions using modified three-dimensional discontinuous deformation analysis incorporating a damped contact model. *Computers and Geotechnics*, *121*, 103456.

Zayyadi, M., Hasanah, S. I., & Surahmi, E. (2018). Ethnomatematics Exploration in Traditional Games As A Form Of Student'Social Interaction. *JIPM (Jurnal Ilmiah Pendidikan Matematika)*, *6*(2), 125–132.

Zhang, Z., Liu, Y., Tian, J., Liu, S., Yang, B., Xiang, L., Yin, L., & Zheng, W. (2021). Study on reconstruction and feature tracking of silicone heart 3D surface. *Sensors*, *21*(22), 7570.