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Exploring Work and Energy Concept with Indonesian Traditional Game "Egrang": An Ethno-pedagogical Approach to Physics Learning

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Abstract: Egrang are a traditional Indonesian game that can be used as a learning medium. This research aims to analyze the physical concepts of work and energy in the traditional game "Egrang" through an ethno-pedagogical approach. This research was conducted with a descriptive review. The learning analysis stage uses a literature review by reviewing several journals to be analyzed in accordance with existing physics concepts, namely the concept of work and energy and ethno-pedagogical approach analysis. The research results found that the concepts of work, kinetic energy, potential energy and mechanical energy can be explained using stilts. And in implementing learning, you can use 5 learning steps with an ethno-pedagogical approach. It is hoped that these results can serve as an initial study at the implementation stage in schools to prove the effectiveness of learning.

Keywords: Ethno-pedagogical; Physics learning; Traditional game

Introduction

Physics is a part of natural science that explains observed phenomena based on rational thinking, human experience, and experiments. Physics can be declared to be very close to everyday life (Sholahuddin & Admoko, 2021). Learning resources include various media such as books, handouts, games and other similar materials (Satria Putra et al., 2022) and games serve effectively capturing students' interest and encouraging engagement in the educational process. Good learning media is learning media adapted to students' circumstances or backgrounds and their learning environment (Dani et al., 2022; Pratama & Retnawati, 2018; Selwyn et al., 2020; Widodo & Wahyudin, 2018). Traditional games are Indonesian local wisdom passed down by ancestors to the next generation (Sulistyaningtyas & Fauziah, 2019; Syahrial et al., 2022) . Traditional games contain high cultural values and are a national cultural heritage that must be preserved (Balletti et al., 2017; Junaedah et al., 2020; Wahyuni et al., 2019; Widiana et al., 2018; Yang et al., 2018).

Traditional games are Indonesian local wisdom passed down by ancestors to the next generation (Syahrial et al., 2022). Traditional games have many benefits, namely they can train children's creativity, control emotions, social intelligence, bring children closer to nature, can develop children's motor skills and so on (Rumiati et al., 2021) . Indonesia has many types of traditional games, one of which is Engrang. A balancing game with long bamboo poles that have wooden supports on the stems to stand on. This traditional game is found in various regions in Indonesia with different names, such as tengkak-tengkak (Sumatra), Jangkungan (Central Java) and Batungkau (South Kalimantan)u (Rumiati et al., 2021). 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 (Fatmawati, 2021)

In the traditional game of stilts there are physics concepts that can be integrated into physics learning. One of them is the concept of work and energy. The problem faced by students in understanding the concept of work and energy in the concept of applying force in the concept of work, is the teacher's difficulty in

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explaining it so that students misinterpret the correlation between gravitational force and the height of an object. Apart from that, students do not know the quantities and units in work and energy material, so they experience difficulties in solving problems. In this case, they must also be skilled at solving problems in their immediate environment (Fatmaryanti et al., 2020) . Research has been carried out by (Rumiati et al., 2021) regarding the analysis of the physical concept of mechanical energy in the traditional game of stilts as a physics learning material, therefore the researchers were inspired to develop this analysis using an ethno pedagogical approach.

Ethno pedagogy is an approach to education that is culturally based (Hidayat et al., 2023). Ethno pedagogy is the actualization of learning to instill the values of local wisdom of an ethnic group (Raharjo et al., 2023) . The integration of ethno pedagogy in science learning can provide meaningful learning for students to develop student engagement and cultural awareness (Rahmawati et al., 2020) .

Based on the description above, the aim of this research is to analyze the physical concepts of work and energy in the traditional game "Egrang" through an ethno pedagogical approach. The benefit of this research is to explore the results of research which can be used as insight and scientific literacy for readers which are applied in everyday life, especially for the continuity of physics learning, it can make it easier for teachers to convey learning to students.

Method

This research was conducted with a descriptive review that has been used in this article. Analysis of traditional games is seen from the entire process when the game is played, accompanied by analysis of physics concepts and analysis of learning steps (Fatmaryanti, 2023) . This method describes, explains and analyzes the physics concepts found in the traditional game of stilts through an ethno pedagogical approach.

Data collection activities are carried out by observation and documentation. The learning analysis stage uses a literature review by reviewing several journals to be analyzed in accordance with existing physics concepts, namely the concepts of work and energy. (Nana, 2019) explained that using the literature review method, data was collected for analysis and then presented as the results of the discussion so that conclusions were obtained so that this research could help teachers and students in the physics learning process. The research design flow can be seen in Figure 2.

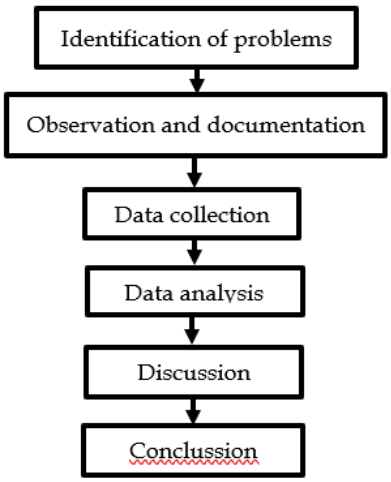

Figure 2. The research design flow

Result and Discussion

Description of Egrang

Egrang is a traditional game played using a pair of bamboo of the same size, approximately 1.5 meters long. The game is then played by running or walking. Usually children playing with run along the start line to the finish line and the first person to reach the finish line are the winner. Egrang consist of two relatively straight old bamboo sticks, each with the diameter of an adult's arm and between 1.5 and 3 meters long, make a hole at the base or one end of the bamboo (approximately 20-30 cm from one of the bamboo roots) and insert bamboo pieces 20 x cm wide as footrests. Tie or nail the bamboo strips and holes, making sure the joints are strong enough to climb through.

Figure 3. Egrang with different heights

Egrang are a skill game that teaches how to maintain balance while walking. This is a fast racing game with a game pattern of running from one side to another then back to the original side. This game is

played by young people, usually boys aged between 10 and 25 years, and only a few girls by holding two bamboo sticks firmly in an upright position, then lifting one of the legs directly onto the bamboo/short piece of wood to accommodate the leg, then lifting the other leg too. In a footrest, the thumb and other toes are clamped, and when balanced, the clamped toes also determine the strength of the holding hand. The results of research on field observations on the traditional game of Egrang (Anas Mukhtar & Gatut Rubiono, 2022; Rumiati et al., 2021; Yoranika & Diyana, 2022) are written in table 1.

Table 1. Physics concepts in Egrang

Physics Concept	Movement	Information
Work	Lift one leg on the stilts, followed by the next leg. When the stilts first stand still then walk	The effort made by the player first starts with his feet on the ground and then climbs onto the stilts and works to move the stilts from the starting position to the final position.
Kinetic energy	Lifting/riding on stilts Holding stilts Pushing on stilts Twisting Movement/turning Walk on stilts Pull your arms towards your body Bend arms, legs and body Masses of stilt players	There is a force that causes the stilt game to move/walk at a certain speed
Potential energy	Player's height Lifting the stilts Stepping on the stilts Lift your thighs away from your body	There is energy in objects because of a certain condition or position or position

Analysis of Work Concepts in the Traditional Game of Egrang

Work in physics is the force exerted to move or move an object, while energy is the ability of an object to do work. In the Egrang game what is called work is the effort made by the player who initially has his feet on the ground and then is able to climb onto the egrang (Figure 4), by balancing his body to be able to walk forward with both feet already on the stilts so that the stilts can move from their position (Figure 5).

Figure 4. Efforts to climb the egrang

Figure 5. Egrang running from the starting position to the final position

The bamboo stick that is held functions as a controller for the movement of objects with the hand as the control. Here the hand muscles function as force producers because they can push and pull. In this traditional game, one player's hand pulls, namely by lifting the bamboo. Meanwhile, the other hand does the pushing, namely when the hand moves the bamboo to move it forward.

In physics, an object moves a distance s due to the influence of a force *(F)* in the direction of the displacement, the work *(W)* done by the force is equal to

the product of the force and the displacement (s). Mathematically it can be written in Equation 1.

$$W = Fs \quad (1)$$

When a player walks forward, we can say there is positive work, meaning that the work is in the direction of the movement of the object. and vice versa, when a player walks backwards, there is negative work, meaning that the work is in the opposite direction to the motion of an object. If the player does not move (does not climb the foothold) then the effort is zero.

Work is not always done on a flat plane, but can also be done on an inclined plane. The difference between work on a flat plane and a plane is that the work on an inclined plane is greater than on a flat plane. The analogy is that when a player walks on a flat track and another person walks on a slanted track, then it is the person walking on the slanted track that requires greater effort.

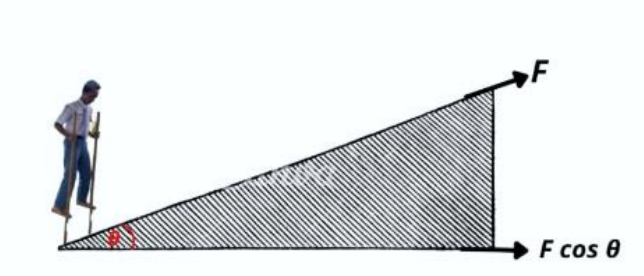

Figure 6. Work on an inclined plane

This happens because of the angle formed by the force. Mathematically it is formulated as Equation 2.

$$W = Fs\cos\theta \quad (2)$$

Analysis of the Energy Concept in the Traditional Game of Egrang

a) Kinetic Energy

The energy possessed by an object due to its motion. The energy possessed by moving objects is kinetic energy (E_k). The amount of kinetic energy is determined by the mass of player (m) and interpreted based on the velocity of player (v) The faster an object moves, the greater the kinetic energy it has. Mathematically, kinetic energy is formulated as Equation 3.

$$E_k = \frac{1}{2} mv^2 \quad (3)$$

Kinetic energy is also influenced by the player's mass, the greater the player's mass, the greater the kinetic energy. This is proven by the fact that a stilt player who has a mass of 58 kg with the same step height of 30 cm has greater kinetic energy as seen in Figure 7.

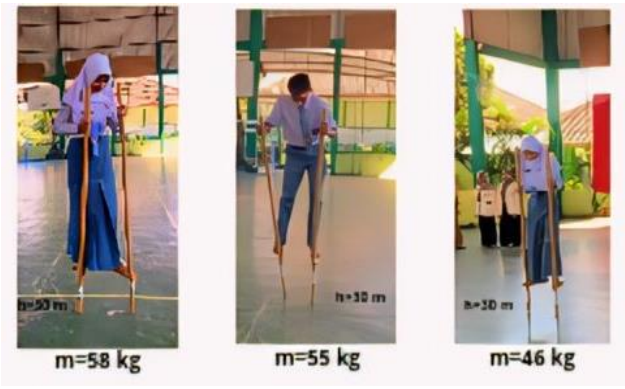

Figure 7. Differences in mass of stilt players

The position of the arms when holding the stilts affects the speed and comfort when walking. The correct arm position is perpendicular to the egrang arms (Rumiati et al., 2021) . Conversely, if the player's arm position is too low or too high, the egrang will slow down. This shows that the force applied by the player affects the kinetic energy of the object (Figure 8).

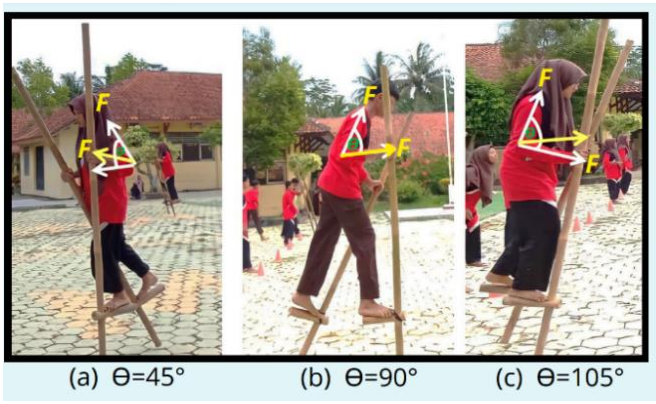

Figure 8. Differences in arm position holding the stilts

Observation results show that in a straight arm position $\theta = 90°$ you can take wide steps so you can quickly reach the end point. Meanwhile, when the arms are down, $\theta = 105°$, step with a small foot width and requires many steps to reach the finish, and when the arms are up, $\theta = 45°$ the step width when walking is not too narrow. The size of the force above is proven to influence walking speed while the game is in progress.

b) Potential Energy

The energy possessed by a stationary object is due to its position or position. Apart from being influenced by position, potential energy is also influenced by the earth's gravitational force. In the analysis of Egrang, the higher the stilt footing, the greater the potential energy, because the greater the distance between the footing and the earth's surface (Rumiati et al., 2021) . Results of potential energy analysis at different heights of Egrang, namely 30 cm, 40 cm and 50 cm.

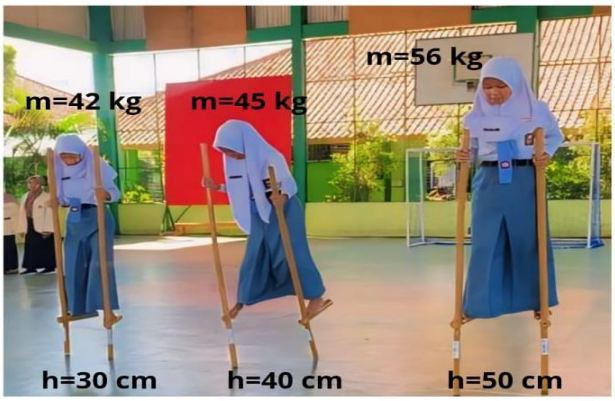

Figure 9. Differences in Egrang step height

Potential energy (E_p) is influenced by mass (m) and position/height (h). The greater the mass of the stilt player, the greater the potential energy, therefore the player with the greatest mass has the greatest potential energy too. Furthermore, the higher the footrest, the greater the potential energy it has. In the figure 9 there are 3 different footholds. The results of observations of stilt players who climb the $h = 50\ cm$ footing have greater potential energy than the height of the foothold $h = 30\ cm$ and $h = 40\ cm$, in the sense of $h = 50\ cm > h = 40\ cm > h = 30\ cm$. Mathematically it is formulated as Equation 4.

$$E_p = mgh \quad (4)$$

c) Mechanical Energy

Motion energy is a combination of kinetic energy (E_k) and potential energy (E_p). Mathematically it is formulated as Equation 5.

$$E_m = E_p + E_k = mgh + \frac{1}{2}mv^2 \quad (5)$$

Analysis of learning steps using an ethno pedagogical approach

Integrated physics learning with an ethno pedagogical approach aims to reconstruct cultural knowledge. The ethno pedagogical approach can improve student learning outcomes and effectively instill social values (Lestari & Bahri, 2021) . There are five stages in the ethno pedagogical approach: self-identification, content integration, collaboration, dialogue, and reflection. The stages of applying egrang in physics learning using an ethno pedagogical approach can be seen in Table 2.

According to (Lestari et al., 2018) ethno pedagogical-based social studies learning through planning and action planning as well as social studies learning through the use of the environment as a learning resource can have a positive impact on students' success in participating in the learning process. Overall, Ethno pedagogy is very important in understanding how culture and education interrelate and influence one another (Selasih & Sudarsana, 2018). Learning physics using an ethno pedagogical approach using stilts is an effective learning in instilling social values such as mutual cooperation, cooperation and integration or unity between them. Learning objectives may not be achieved optimally if the learning design is not organized and extensive. Apart from that, students' abilities also cannot increase according to the learning objectives that have been set (Lee, CJ, & Kim, 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., 2022). Teachers must help students discover their own concepts through their own creativity.

Table 2. Learning activities at each step of the ethno pedagogical approach with traditional games

Stages	Learning Activities
Self-identify	Identifying the culture around students through traditional games
Integration of science and culture content	Construct the knowledge of work and energy that students have previously acquired and ask about the relationship between the concepts of work and energy and the traditional game of egrang
Collaboration	In groups, students play stilts and analyze the concepts of work and energy in egrang
Dialogue	Convey the results of discussions in class, and other students provide input to improve learning
Reflection	Reflecting on learning activities that have been carried out and evaluating

The goal is to make knowledge stick in your mind by prioritizing the process over the results (Kivunja, C., & Kuyini, 2017) . So, in the first stage, identifying the culture that exists in the environment around the students, the teacher gives examples such as traditional dance, musical instruments, traditional games, traditional food, etc. The teacher takes one of these examples, namely traditional games. In the second stage, the teacher asked about the types of traditional games that the students knew, one of which was the Egrang. At this stage, the teacher also constructs the knowledge of effort and energy that students have previously acquired. The teacher conveys the concept of effort and energy related to game. And then discuss quantities and units contained in work and energy material, types of energy, the influence of the mass of the stilt player on

kinetic energy, the influence of step height on the amount of potential energy and then arouse students' curiosity about this knowledge so that they invite students to ask questions. In the third stage, the teacher guides the students into several groups to practice egrang, as well as analyzing the concepts of work and energy on stilts. In the fourth stage, the teacher guides the discussion session regarding problems found when analyzing the concepts of work and energy and other students provide input to improve learning. The final stage reflects on the learning activities that have been carried out and evaluates them in the form of tests or quizzes, assignments, presentations.

All stages of learning show a relationship between teaching approaches and learning achievement. Students' knowledge can be improved by encouraging mastery goals, not performance goals (Meece, 2023) . Through this learning, students gain new experiences in studying science that is linked to their local culture. Throughout the self-identification stage, the teacher as a facilitator must pay attention to the students' cultural background and character to engage students in the learning process. Thus, an ethno pedagogical approach in physics learning can provide students with meaningful learning, develop student involvement, and cultural awareness, because students not only learn concepts, but also learn how science concepts are applied in their local culture through project creation activities.

Conclusion

Based on the results that have been carried out from several analyzes and observations, it is concluded that the traditional game Egrang has a lot of potential for the development of physics concepts including: work and energy. In this research, we conclude that there is a need for innovation by physics teachers to help students understand the material more easily by connecting physics material through an ethno pedagogic approach or anything related to students' lives to get meaning from physics. Using an ethno pedagogical approach as a learning tool can have a positive impact on students' success in following the physics learning process.

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Author Contributions
Concept physics analysis – writing the original draft, R.W., writing – review, S.D.F. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest
The authors declare no conflict of interest.

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