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A Study of Physics Concepts in *Pari'i Tillu* Withdrawal Tradition of Loli Tribe's Traditional House: Integration of Culture-Based Physics Learning

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Abstract

This research explores the physics concept contained in the *Pari'i Tillu* withdrawal tradition carried out by the Loli ethnic group. The method used in this research is descriptive qualitative with an ethnographic approach carried out in five stages: preliminary studies, research instrument development, data collection and analysis, integration of research results, report writing, and publication. This research involved five resource persons who are indigenous people of the Loli ethnic group. This study found that there are physics concepts in the tradition of pulling *Pari'i Tillu* while building the Loli tribe's traditional house. Newton's first law is the physics concept found when *Pari'i Tillu* is placed at a standstill. Newton's Law II was applied when the people pulled a pole from the forest to the house building site. Newton's Law III occurs during the action-reaction force between the hand and *Pari'i Tillu*. Weight force is observable in the process of pulling *Pari'i Tillu* because objects with a certain mass always point to the center of the Earth due to the gravitational force of the Earth. Normal force is found on *Pari'i Tillu*, which lies on the surface of the ground and the surface of the round wooden pads, as the touch pad. The concept of work is found in the amount of force exerted by the people to remove *Pari'i Tillu*. Friction force occurs when there is friction between the pole and the ground.

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INTRODUCTION

Physics is one of the core subjects in the curriculum, which studies the basic principles of the universe and natural phenomena in the surrounding environment. The purpose of learning physics is not only to understand basic concepts but also to develop critical, analytical, and creative thinking skills and be able to apply physics concepts in the context of life, both in the fields of science and technology (Ahmad et al., 2021; Bakri et al., 2023).

Learning physics is often considered difficult because it comes from an abstract and conceptual nature and requires a strong understanding of mathematics. Currently, the challenges faced by students in learning physics are densely packed physics material, a lot of counting, and the lack of instruments that train higher-order thinking skills (Garung, 2022, Kahar et al., 2021; Sari et al., 2022). Furthermore, low problem-solving skills and examples of the application of physics concepts are still general or even rarely known by students (Abdullah et al., 2015; Arnellis et al., 2021; Rumiati et al., 2021; Samudra et al.,

2014). This condition can lead to the inability of students to understand the context of the problem during problem solving (Retno et al., 2019; Tawfik et al, 2018).

Data on the level of ability of students to solve physics HOTS questions is obtained as follows: 57.06% ability to analyze in the medium category, 51.23% in the medium category, and 38.47% in the low category (Kulata et al., 2023; Megawati et al., 2020). This data is supported by the results of the PISA survey on Indonesian students' science literacy of 383 points, which decreased by 13 points from the previous survey year (OECD, 2024). Based on data from the Education Report Card issued by the Ministry of Education and Culture (2024), it was found that less than 40% of primary and secondary school students in Southwest Sumba achieved the minimum competency of literacy in the deficient category. The study results (Putri et al., 2022) found that students' difficulties in solving physics problems were a lack of mathematical calculation skills, difficulty in understanding physics problems in essay form, and difficulty distinguishing physics equations. These results show that students' science literacy is the main focus in the process of improving education. Therefore, it is very important to improve the quality of physics learning to train high-order thinking skills (HOTS).

The attempts that have been made to improve students' science literacy include implementing models, media, teaching resources, and the use of technology in the curriculum (Fang & Wei, 2018; Garung, 2022; Winarni et al., 2022). However, many curriculum and teaching resources are mostly focused on universal scientific knowledge and pay less attention to the local context. In fact, integrating local culture into the curriculum can make learning more contextualized and can strengthen the cultural identity of the younger generation (Annisha, 2024; Elisa et al., 2022).

The degradation of the cultural heritage of the younger generation can be reflected in the style of dress and language that tends to use foreign languages in order to be seen as more modern. The revitalisation program of 5 regional languages in East Nusa Tenggara, such as Dawan language, Manggarai language, Kambera language, Rote language, and Abui language, is a concrete proof that cultural identity has declined and is threatened with extinction (Kemendikbudristek, 2022). During this time, the learning resources used in physics learning are still general; examples of the application of physics concepts in textbooks are very rarely found in the real life of students, so teachers often provide other examples to help students understand the material. In fact, the meaningfulness and continuity of physics learning are contained in learning materials that will be in direct contact with daily life activities in the environment. By bringing up the local wisdom of local Sumba, it is expected to create more contextual physics learning.

Another unique cultural heritage in Sumba Island is the *Pari'i Tillu* Withdrawal Tradition during the construction of the Loli tribe's traditional house. Through this tradition, the younger generation can understand their cultural identity; this certainly also contributes to the development of cultural literacy. Knowing and appreciating culture is one of the key elements of global diversity (Indawati, 2022; Cuccurullo & Cinganotto, 2020; Pless & Maak, 2004).

According to the information above, it is important to innovate physics learning that is able to simplify abstract physics concepts using cases that are often found in the surrounding environment. This research analyzes how the concept of physics is contained in the tradition of *Pari'i Tillu* withdrawal carried out by the Loli Tribe in West Sumba.

METHODS

The type of research used is descriptive qualitative with an ethnographic approach through observation, interview, and documentation studies. The subjects of this research are five tribal leaders (Rato Rumat) who can provide an overview and explanation about the process of pulling a large pole (*Pari'i Tillu*) and be able to describe the cultural philosophical

meaning in the tradition of pulling *Pari'i Tillu*. The respondents in this study can be seen in Table 1.

Table 1 Research respondents

No.	Respondent	Initial
1	ABNUR	R1
2	YBL	R2
3	KNMA	R3
4	LMM	R4
5	SBM	R5

The research was conducted in Tarung site village and Waitabar site village, Loli sub-district, West Sumba Regency. Indicators of the interview guidelines used in this study were adapted from (Sudarmin, 2014) and can be seen in Table 2.

Table 2 Interview guidelines indicator

Variable	Indicator
Cultural aspects of the tradition of pulling a large pole (*Pari'i Tillu*) in the traditional house of the Loli Tribe's.	1. Cultural identity of the Loli people, West Sumba Regency in the building of traditional houses 2. The process of pulling the large pole *(Pari'i Tillu)* 3. Equipment / tools and materials needed in the process of pulling a large pole *(Pari'i Tillu)*

The aspects of the observation guidelines used in this study were adapted from (Sudarmin, 2014) and can be seen in Table 3.

Table 3 Observation guideline instrument

Variable	Indicator
Physics aspect	Regarding the physics concept contained in the process of pulling the large pole (*Pari'i Tillu*).

The data analysis technique in this study is to use the Miles & Huberman model of analysis consisting of three activity streams, as follows: data reduction, data presentation, conclusion drawing/verification. This research process is divided into five stages, which can be described in Figure 1.

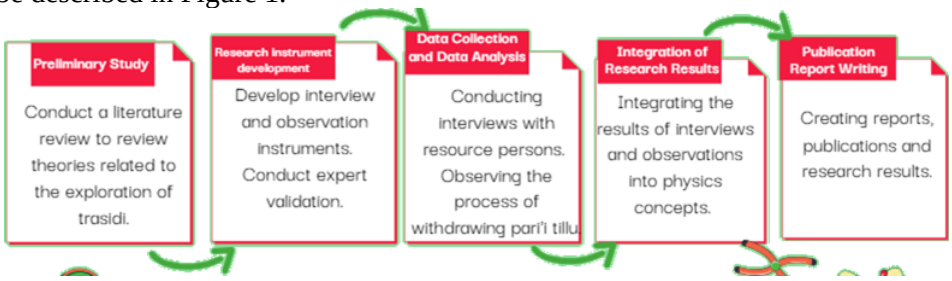

Figure 1 Research steps

RESULT AND DISCUSSION

The Tradition of Withdrawing *Pari'i Tillu* from the Loli tribe of West Sumba Regency

The *Pari'i Tillu* withdrawal tradition is one of the traditions in building a traditional Loli tribal house. The traditional house of the Loli Tribe has a conical shape with a towering tower. This shape symbolizes the harmonious relationship between humans and the spirits of the ancestors (Marapu). Four large poles (*Pari'i Tillu*) support the entire building as a symbol of the four wind directions. The traditional house of the Loli tribe can be seen in Figure 2.

Figure 2 The traditional house of the loli tribe

The ritual of pulling *Pari'i Tillu* is also known as Tengngi Pari'i, which means pulling the pole; in traditional language, it is called “Wela Poga Tengngi Tuwa.” The philosophical meaning of *Pari'i Tillu* is to support the life of the people in the house or to guard life.

The *Pari'i Tillu* pulling tradition is carried out when a tribe wants to build a traditional house. The activity begins with asking permission from the ancestors through the ritual of reading traditional poetry, commonly called “mbara manu or nobba ana manu.” After getting permission from the ancestors, they search for trees that will be used for *Pari'i Tillu*. The search process is done in groups; each group looks for one tree that is appropriate to *Pari'i Tillu's* requirements. When the tree is found, the first thing done by the people is to give a sign, or in traditional language, called pakabeko. In their belief, this action is carried out so that the tree can become paralyzed and not change its form or disappear. After that, a ritual asking permission to cut down the tree is followed. This tradition reflects the ethical values towards nature embraced by the local community by showing that nature, including trees, has the right to live; taking something from nature must be done with full consideration and not excessively.

After cutting down the tree, the next step is to clean the bark, branches, and twigs to make it easier to pull. Pulling the tree is traditionally done using wooden pads and natural rope (uwe) to reduce friction. The pulling of *Pari'i Tillu* in the Loli traditional house is still carried out in accordance with Marapu traditional beliefs, so the equipment used is from nature. The pulling process can be seen in Figure 3.

Figure 3 *Pari'i Tillu* pulling process

The Concept of Physics in the *Pari'i Tillu* Withdrawal Tradition

The tradition of pulling *Pari'i Tillu* in the traditional house building of the Loli tribe uses traditional methods that indirectly contain physics concepts, especially in pulling traditional house poles from the forest to the house building site. The results of the analysis of physics concepts found in the tradition of pulling *Pari'i Tillu* are as follows.

Newton's First Law

In this condition, Newton's first law applies: "If the resultant force acting on an object is equal to zero, then an object that is initially at rest will remain at rest. Then an object initially moving in a straight line will continue to move in a straight line with a fixed acceleration." Newton's first law is formulated as follows (Giancoli, 2014).

$$\Sigma F = 0 \quad \ldots (1)$$

Description:
$\boldsymbol{\Sigma F}$ = Force resultant (N)

According to Newton's first law, objects tend to maintain their state in the tradition of pulling *Pari'i Tillu*. Figure 3 shows the application of Newton's first law to the *Pari'i Tillu* pulling tradition.

Figure 3 Illustration of Newton's first law

The Loli people pull the *pari'I tillu,* which initially lies on the ground stationary (Figure 3). It shows that the forces acting on the object are balanced (e.g. weight W and normal force N). The object will remain at rest because there is no horizontal force large enough to pull. This context is relevant to the concept of Newton's first law, also known as the law of inertia. When people start pulling the *pari'I tillu* with a force greater than the frictional force with the ground, the object will change from being at rest to moving. However, if the pulling force is insufficient to overcome the friction, the *pari'I tillu* will remain at rest. This characteristic is called inertia, which is the property of maintaining its position. When after *pari'I tillu* moves at a constant speed, it shows that the friction force balances the pulling force exerted. This shows that an object that has moved will continue to move if no external force stops its motion.

Newton's Second Law

In the process of pulling *Pari'i Tillu*, there is the concept of Newton's second law, which explains that the force (F) exerted on an object will increase the speed of the object, and if the force exerted is opposite to the motion of the object, it will reduce the speed. Other than the force, mass also affects the object's speed, such that the greater the mass, the greater the force needed to move an object. This mathematical correlation is presented by Newton, who states that "the acceleration of an object is directly proportional to the total force acting on it and inversely proportional to the mass. The direction of acceleration is the same as the direction of the total force acting on it" (Giancoli, 2014).

$$a = \frac{\Sigma F}{m} \quad \ldots (2)$$

Description:
a = Acceleration ($〚m/s〛$ ^2)
ΣF = Force resultant (N)
m = Mass (kg)
The illustration concept of Newton's second law in Pari'i Tillu withdrawal is shown in Figure 4.

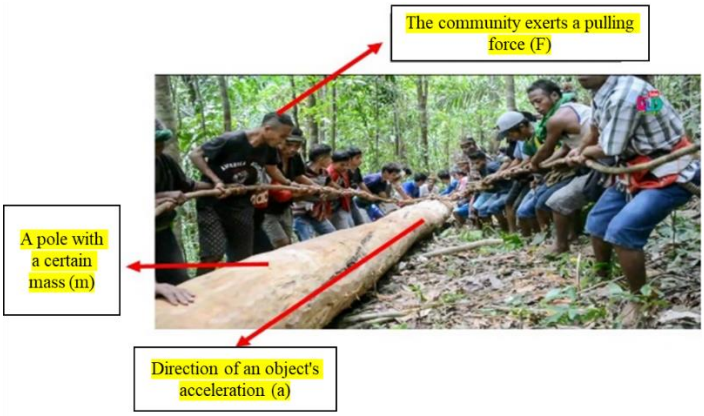

Figure 4 Illustration of Newton's second law

Many Loli tribe communities collectively pull *Pari'I Tillu* from the forest to the building site of the traditional house (Figure 4). In the picture, several physical elements relate to the activities carried out. People act as a pulling force on the pari'i tillu by using ropes. The greater the force applied, the more likely the wood is to move faster. In addition, *Pari'Tillu* has a certain mass that can determine how difficult it is to move to the building site of a traditional house. The greater the mass, the more force (F) is needed to move it. In the process of pulling the *pari'tillu* experiences acceleration due to the direction of pull according to the force exerted by the community. The greater the force applied, the *Pari'I tillu* will begin to move and accelerate.

Newton's Third Law

When they pull a tree from the forest to the building site of a traditional house, the people use a natural rope to carry the tree. This activity identified the concept of Newton's third law. Newton's Law III, commonly known as the action-reaction law, states that "when an object exerts a force on a second object, the second object will exert a force of the same magnitude but in the opposite direction." This action-reaction force only works on two different objects. Newton's third law can be formulated as follows (Giancoli, 2014).

$$F_{action} = F_{reaction} \quad \ldots (3)$$

Description:
F_aksi = Exerted force (N)
F_reaksi = Force received (N)

The illustration of the action-reaction forces in the Pari'i Tillu pulling process is shown in Figure 5. The process of pulling Pari'I Tillu is carried out using a forest rope to move it to the construction site of the traditional house (Figure 5). In Figure 5, several elements of physics are relevant to Newton's third law. The Loli people pull the Pari'I Tillu with a Pull Force (F_{action}) using a rope as shown by the red arrow. This force seeks to move Pari'I till in a certain direction. While exerting an action force, the pari'I tillu exerts a reaction force ($F_{reaction}$) that is equal in magnitude but opposite in direction (represented by the black arrows). This process shows that any force applied to an object will get a reaction and a reaction force.

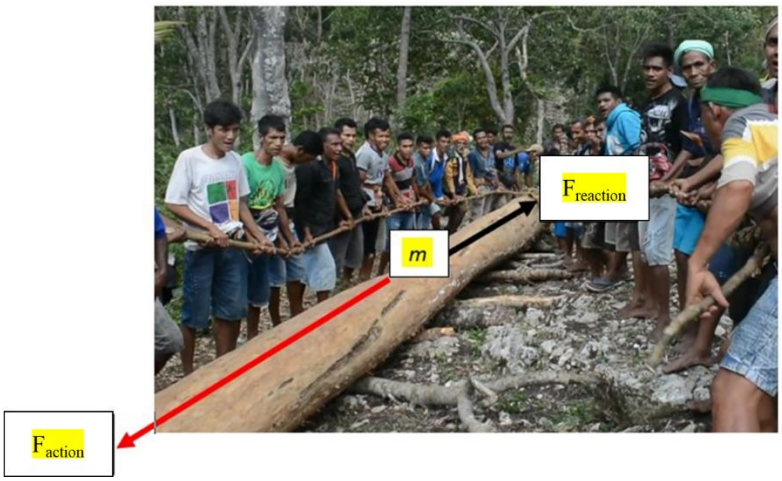

Figure 5 The illustration Newton's third law

Work (W)

Work is the energy exerted to move an object or an item. In dragging *Pari'i Tillu*, a significant amount of work is required to move the pole to the traditional house building site. Work is defined as multiplying the amount of displacement by the component of force that is parallel to the displacement. (Giancoli, 2014). The mathematical formulation can be formulated as follows:

$$W = F.s \quad \ldots (4)$$

Description:
W = Work $(N\ /\ m)$
F = Force (N)
s = Displacement (m)

The equation above applies if the force exerted on the object is parallel to the object's displacement direction. Illustration of Effort Parallel to the direction of displacement as shown in Figure 6.

Figure 6 Illustration of effort parallel to the direction of displacement

However, if the force exerted creates a certain angle to the displacement of the object, then the work equation is as follows (Giancoli, 2014).

$$W = F.s\ cos\ \theta \quad \ldots (5)$$

Description:
W = Work $(N\ /\ m)$
F = Force (N)
s = Displacement (m)
θ = Angle (θ)

Illustration of work if the force creates an angle to the displacement as shown in Figure 7.

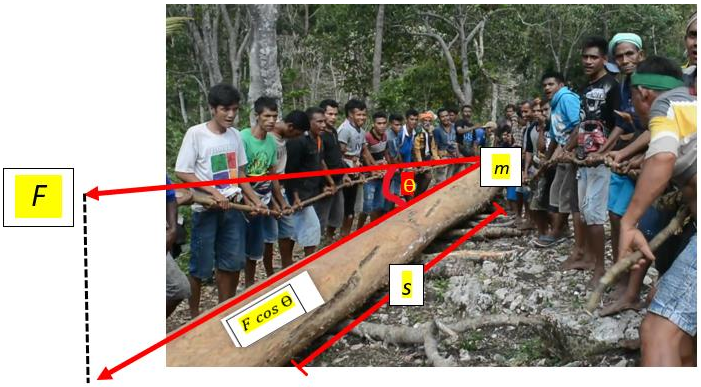

Figure 7 Illustration of work if the force creates an angle to the displacement

The process of pulling *pari'I tillu* involves the concept of work, to move objects from the forest to the building site of the traditional house (Figure 6 and Figure 7). The figure reflects that Community Cooperation to overcome obstacles in moving heavy objects relies on the concept of work. People exert the pulling force (F) shown by the red arrow. This force is applied in the horizontal direction to move the *pari'tillu*. As a result of the force applied, the *Pari'i Tillu* changes its movement (s). The greater the movement value, the greater the effort made by the people to move the *Pari'i Tillu*. Because the force (F) is in the same direction as the movement (s), the work given by the people is maximum.

Weight force (w)

During the felling of the tree to be used as *Pari'i Tillu*, the tree will fall to the ground. This condition is identified as one of the applications of the weight force. According to the theory of Galileo, a dropped object will have an accelerating force of attraction of the Earth if the drag of the Earth is ignored (Giancoli, 2014). The weight force can be described in the following equation:

$$w = m.g \quad \ldots (6)$$

Description:
w = Weight force (N)
m = Object mass (kg)
g = Gravity (m/s^2)
Illustration of the weight force as shown in Figure 8.

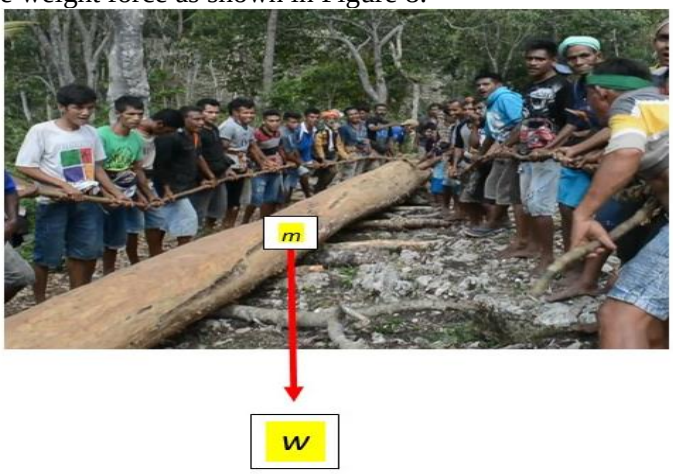

Figure 8 Illustration of the weight force

Figure 8 shows that the felled tree fell to the ground because it was affected by gravitational forces (g). This is in accordance with the concept of weight force (w), which states that an object with a certain mass is always affected by the Earth's gravity (g).

Normal Force (N)

Along with being affected by the weight force, trees that have been cut down also have a normal force. A normal force acts on two surfaces that touch each other and have a direction perpendicular to the touch area. If the *Pari'i Tillu* is lying on an inclined plane, the equation for the normal force that applies to the object is given below.

$$\Sigma F = 0$$
$$N - w\ cos\ \theta = 0$$
$$N = w\ cos\ \theta \quad \ldots (7)$$

Description:
N = normal force (N)
w = weight force (N)
θ = angle (θ)

If the Pari'i Tillu lies on a flat surface, the equation for the normal force that acts on the object is shown below:

$$N = w$$
$$N = m.g \quad \ldots (8)$$

Description:
N = normal force (N)
w = weight force (N)
m = Object mass (kg)
g = gravity ($m\ /\ s^2$)

Figure 9 illustrates the normal force that works when pulling the traditional house pole.

Figure 9 Illustration of the normal force

Pari'I Tillu, which is at ground level, has two main forces acting on it, namely the normal force and gravity (Figure 9). The normal force is shown in the upward arrow, and this force is exerted by the ground on the object in reaction to gravity. The downward arrow shows the weight force. This force occurs due to the acceleration of gravity that pulls the object toward the Earth's center. As *Pari'i Tillu* is above ground level and does not move significantly up or down, it is concluded that the object is in a state of equilibrium.

Friction force (f)

The force that acts due to two surfaces touching each other is known as the friction force. The friction force is a force that is directed against the object's motion or the direction in

which the object intends to move (Giancoli, 2014). The friction force can be divided into two as follows:

Static friction force (fs)

The static friction force is the forces of friction that act on the surfaces of objects in contact when the objects have not been moving. Therefore, it can be stated that the static friction force is the friction force that acts on a stationary object. The following equation can describe the amount of the static friction force:

$$fs = \mu_s N \quad \ldots (9)$$

Description:
fs = Static friction force (N)
μ_s = Coefficients of static friction force
N = Normal force (N)

Kinetic friction force (fk)

Kinetic friction is the force that acts on two surfaces of an object that are in contact when the object is moving. Therefore, it can be said that kinetic friction is the frictional force acting on an object when it is moving. The following equation can describe the kinetic friction force (Giancoli, 2014).

$$fk = \mu_k N \quad \ldots (10)$$

Description:
fk = Kinetic friction force (N)
μ_k = Coefficients of kinetic friction force
N = Normal Force (N)
Illustration of the Friction Force as shown in Figure 10.

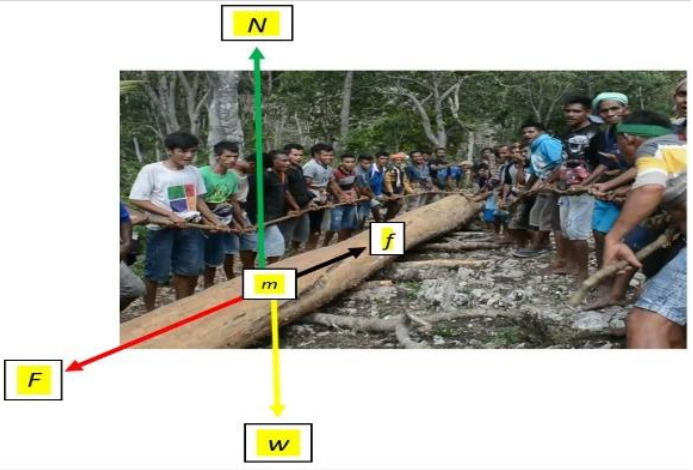

Figure 10 Illustration of the friction force

From Figure 10, it can be explained that the process of pulling *Pari'i Tillu* from the forest to the traditional house building site, initially, the pole is placed on the ground, so that it tends to be difficult to pull because there is significant friction between the pole and the ground. To simplify the pulling out of the poles, the people arranged wooden pads on the ground along the path that the poles would pass through to reduce the frictional force between the pole and the wooden pad. In this process two types of friction forces work, such as static friction force (fs) and kinetic friction force (fk), static friction force (fs) works when the pole is at rest and then about to be given a force, while kinetic friction force (fk) works when the pole moves with decreasing speed until it stops.

Implementation of Physics Concepts Based on Pari'i Tillu Tradition in Physics Learning

Integrasi The integration of *Pari'i Tillu* tradition in physics learning aims to help students understand the contextual concept of seeing science as something relevant to their daily lives and as an effort to instill local cultural values in the younger generation. The study of physics concepts based on *Pari'i Tillu* tradition can be implemented in physics learning as shown in Table 4.

Table 4 Study of physics concepts based on *pari'i tillu* tradition in physics learning

No.	Physics Concepts	Essential Competency	Competency Achievement Indicator	Education Unit
1	Newton's 1st Law	3.7 Analyze the interaction of forces and the interaction between force, mass, and the motion of objects in straight motion.	Identify the implementation of the principle of Newton's 1st law (law of inertia) in daily life.	Senior High School Class X
2	Newton's 2nd Law	3.7 Analyze the interaction of forces and the relations between force, mass, and the motion of objects in straight motion.	Identify the implementation of Newton's 2nd law principle in everyday life.	Senior High School Class X
3	Newton's 3rd Law	3.7 Analyze the interaction of forces and the relations between force, mass, and the motion of objects in straight motion.	Identify the implementation of Newton's 3rd law principle in everyday life.	Senior High School Class X
4.	Work	3.9 Analyze the concepts of energy, work (effort), the relationship between work (effort) and energy changes, the law of energy conservation, and its implementation in daily events.	Formalize the relations between force, energy, work, and power into a simple form.	Senior High School Class X
5.	Weight Force	6.1 Identify the types of forces, the sum of forces, and their effect on an object that receives a force.	Illustrating the sum of forces and the difference of forces in line, both in the same and opposite directions.	Junior high school class VIII
6.	Normal Force	6.1 Identify the types of forces, the sum of forces, and their effect on an object that receives a force.	Illustrating the sum of forces and the difference of forces in line in the same and opposite directions.	Junior high school class VIII
7.	Static Friction Force	6.1 Identify the types of forces, the sum of forces and their effect on an object that receives a force.	Determine the amount of friction force on various surfaces that differ in roughness, such as smooth, slightly rough, and rough surfaces.	Junior high school class VIII
8.	Kinetic Friction Force	6.1 Identify the types of forces, the sum of forces, and their effect on an object that receives a force.	Determine the amount of friction force on various surfaces that differ in roughness, such as smooth, slightly rough, and rough surfaces.	Junior high school class VIII

*SMA: Senior High School
*SMP: Junior High School

According to Table 4, integrating *Pari'i Tillu* tradition in physics learning could create a more contextualized learning experience. Contextualized physics concepts can support the development of 21st-century competencies, such as critical and creative thinking, by integrating modern science and daily life (Pertiwi et al., 2024; Kelley & Knowles, 2016). This process provides a more in-depth, meaningful, and relevant learning experience for students' lives.

CONCLUSION

During *Pari'i Tillu* ceremonies, people from the community work together to bring a large wooden pole from the forest to the construction site of their traditional house. This custom upholds the value of gotong royong since everyone must work together and feel united to achieve their common objective. This traditional practice shows the community members their love for nature because they use forest resources properly during the ceremony.

When participants grasp the *Pari'i Tillu* pole, physics shows that Newton's Third Law works through opposing forces that develop between their hands and the pole. During pulling, objects adopt their natural gravitational path toward Earth's center because of the planet Earth's gravitational force. The normal force works at every point where the *Pari'i Tillu* pole touches the ground surface and the log bearings. The entire community applies physical strength to achieve motion with the pole. When the pole touches the ground surface, it experiences two types of forces: frictional contact with the earth. By continuing *Pari'i Tillu* rituals, young people learn traditional customs that help them preserve their cultural identity. Every person shows social responsibility by helping others with their cultural activities under this tradition.

The *Pari'i Tillu* method allows educational combinations by uniting traditional understanding with contemporary science. Teachers can design meaningful training models by studying how physics relates to the *Pari'i Tillu* activities. Through this method, students will learn physics better while learning to value traditional wisdom.

This research needs more development because it only studies the features of the *Pari'i Tillu* tradition and their link to physics learning. Our study provides a base for information to develop future research projects on the *Pari'i Tillu* tradition and physics learning tools. This study develops better techniques for teaching physics using students' social backgrounds combined with efforts to save Indigenous knowledge from erosion in education.

CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest.

AUTHOR CONTRIBUTIONS STATEMENT

All authors have contributed to the conceptualization, methodology, formal analysis, investigation, and writing this article.

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