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Identification of Physics Concepts in Tumimperas Waterfall in Thematic-Exploration-Democratic Learning (Ted-L): Overview Of Mechanics Aspects

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Abstract

This research aims to identify the concepts of physics at a waterfall in this case the tumimperas waterfall in the Thematic-Exploration-Democratic Learning (TED-L) activity. The tumimperas waterfall is a natural tourist attraction that is often visited by the public. The tumimperas waterfall is still rarely used as an education object in learning especially in learning physics. The tumimperas waterfall contains deep and interesting physics concepts to be identified especially in the study of mechanics. In the process of learning to identify the physics concept done in TED learning activities. The research process is done qualitatively with data gathering techniques by doing observation and documentation study; and the to analyze the data is done with reducing the data. In the process of identifying the concepts of mechanics that acquired are the concept of parabolic motion, mechanical energy, momentum, collision, and air friction which can be observed directly at the tumimperas waterfall.

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INTRODUCTION

Physics learning emphasizes teaching about why and how the phenomena occur in everyday life. (Fitriana, 2017). In learning physics there needs to be interaction with nature through observations done in nature, this is because physics is a branch of natural science obtained by the experts through observations of facts, issues, phenomena that occurs in nature and everyday life. Through the research of experts, represents, analyzes, and describes the explanation of the observed natural phenomenon. (Lahope, K. S., 2020).

Physics learning activities at the highschool are more often carried out inside the classroom, where the students only receive explanations from the teacher and physics textbook used in the school. Learning activities need to be accompanied with direct field observation where the learning process must be contextual. (Prasetyo, D., 2021). Through learning activities in the nature makes the students can give a meaning about what they learn and also can attract attention where the students tend to be active in learning.. the students have a fendency to like physics learning that is carried out outside the classroom by observing the learning objects compared to learning inside the classroom. (Tulandi, D. A., 2022). This kind of learning activities that is Thematic-Explorative-Democratic (TED-L).

TED-L is a learning activity that encourages the students in reconstructing their experience through exploration activities. In the process of learning TED is an activity to reconstruct the experience that begins with exploration of empirical expiriences about facts followed by exploration of the concepts and processes. Through Thematics-Explorative-Democratic Learning, the students are guided to be able to create independent and group learning to create a democratic values. TED-L contains three aspects, that is, Thematic, Explorative, and Democratic. In this research, the emphasis is on explorative activities where explorative activities are activities to observe problems that are not clear, and to emphasize the observation and analysis of “hidden reality” to obtain an explanation about cause and effect relationships and produce new approaches in problem solving. (Medellu, Ch., 2019).

Waterfalls is one of the natural phenomenon that occurs naturally. Waterfalls are often utilized by several parties to be used as tourist attractions, with the restoration of tourism. Tourism restoration is carried out as an effort to recover and restore natural or cultural tourist attraction that have suffered damage or a decrease in quality. Other than being used as a natural tourist attraction, waterfalls can also be used as a learning center, especially for learning physics.. one of the attractions that can be utilized as a physics learning center is tumimperas waterfall.

The tumimperas waterfall has been known since the Dutch colonial era, around 1880. At that time this waterfall was known for the melodious sound of water falling on the rocks below, the melodious sound of falling water in the local language of Tombulu is Tumimperas. Therefore, the name Tumimperas comes from the term water falls down and raises melodious sounds. This waterfall has a height around 52 meters. The location of the waterfall can be utilized as an object of exploration in Thematic-Explorative-Democratic Learning (TED-L) to identify the observeable physics concepts, that begins with facts, issues and phenomena

METHODS

The implementation of this research that uses qualitative research method. Qualitative research is a research method that produces descriptive data verbally and behaviorally gained from the subjects or objects that are being observed. (Jefriyanto, 2022). More specifically, this research emphasizes on analyzing descriptions related to the object of research in this case related to existing facts, issues, and phenomenon.. the object of this research is tumimperas waterfall that is located in pinaras village, south tomohon sub-district, tomohon city, north Sulawesi province. Data collection techniques were carried out by means of observation and documentation studies. In the observation stage, researches made direct observations by exploring natural phenomena that occur in waterfalls. Documentation study is done by taking pictures of the object to be studied. Data analysis is done by reducing data. Reducing data is done by selecting data that is considered important, namely in the form of new data that is not yet known, unique data that is different from the other data, and is relevant data. (Sugyono, 2017).

RESULT AND DISCUSSION

The Thematics-Explorative-Democratic Learning (TED-L) activity begins with the provision of themes at several stages in TED-L learning activities. The theme taken in learning is “Travelling to the Waterfall”. Exploration activities are carried out by identifying and describing facts, issues, phenomena that exists in the waterfall as in Figure-1.

Figure-1. Tumimperas Waterfall

The exploration process in TED-L learning activities consists of four stages, that is (1) identification of facts, issues, phenomena; (2) descriptive analysis of facts, issues, phenomena; (3) exploration of physics concepts; and (4) concept formulation. (The results of exploration in identifying and describing facts, issues, and phenomena in the waterfall can be seen in Table-1.)

Table-1. Identification and Descriptive Analysis of Facts, Issues, Phenomena in Tumimperas Waterfalls

Identifying Facts, Issues, And Phenomena	Analys Description Facts, Issues, And Phenomena
A. water floating in a parabolic trajectory	the water floats to form a parabolic trajectory and falls down to the plunge pool due to the force of gravity. The trajectory of the falling water forms a parabolic trajectory due to the large speed of the water. When floating, the potential energy possessed by the water particles is partially converted into kinetic energy and the water looks white caused by the friction of water with air, and the collision of water with the cliff walls. There is a changein energy from potential energy to kinetic energy.
B. Wind blowing when the water falls	A mass of water at a height has maximum potential energy. As the water falls the potential energy turns into kinetic energy and the speed of the falling water is also large. As the water falls, it collides with air particles and due to the elastic nature of wind, upon collision the air is blown away

Identifying Facts, Issues, And Phenomena	Analys Description Facts, Issues, And Phenomena
	causinga gust of wind.
C. falling water collides with the surface of the plunge pool	there is a sound when water collides with the surface of the plunge pool. The collision of the falling water with the plunge pool surface causes the water to look white, especially the area where it collides and splashes appear.
D. there is erosion of the rock around the water flow	the slope at the bottom of the water causes water to flow. The flowing wate has kinetic energy and when flowing water rubs against the surrounding rocks, causing the erosion of rocks by water and the eroded rocks by the water and the eroded rock material is carried away by the water.
E. the plunge pool where the water falls looks murkier	the height of the waterfall affects the speed at which the water falls. As the waterfalls, it collides with the plunge pool surface and the ground, causing the ground to be dug up and the water to look murkier.
F. there is visible scattering of water particles when water falls onto the surface of the plunge pool	the water particles falling from high places have a very large speed so that when they collide with the surface of the waterfall, the water becomes scattered

From the identification and analysis of facts, issues, phenomena shown in Table-1, several physics concepts can be identified.

1. Parabolic Motion

Parabolic motion is the motion of an object that forms a parabolic trajectory, parabolic motion is formed through the combination of two motions, namely Regular Straight Motion and Regularly Changing Straight Motion, which are expressed in the projection of x-axis and y-axis coordinates. The position of particles in parabolic motion is expressed in the following equation.

$$x = v\_x\, t \tag{1}$$

$$y = y_0 + v_y t + \frac{1}{2} a_y t^2 \tag{2}$$

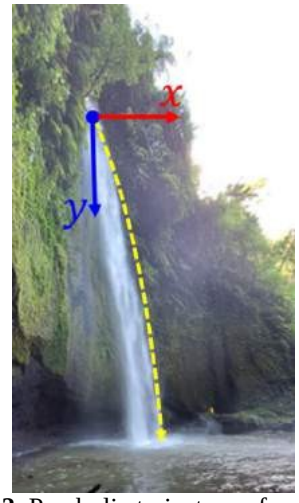


Figure-2. Parabolic trajectory of a waterfall

2. Velocity

Velocity is the change in position per time unit. As seen in the waterfall, by reviewing the motion of waterfall particles moving in parabolic trajectory, the velocity, the velocity of the object is described in x-axis (horizontal axis) and y-axis (vertical axis) coordinates as seen in Figure-2. The velocity of water particles on a parabolic trajectory for the x-axis coordinate is always constant, while the velocity of objects on the y-axis is always changing. The equation for the velocity of an object on a parabolic trajectory in a waterfall is as follows.

$$v_x = v\cos\theta \tag{3}$$

$$v_y = v\sin\theta \tag{4}$$

3. Mechanical Energy

Mechanical energy is a sum of kinetic energy and potential energy contained in an object or the total energy while the object is moving (Syukur, 1992). As seen in the waterfall, the water particles that float down to the plunge pool undergo a process of energy change from potential energy to kinetic energy. In the occurrence of a water falling due to the influence of height which then falls into the plunge pool illustrates the change of potential energy into kinetic energy. This shows that the mechanical energy in the initial position and the next position is the same. Therefore the mechanical energy along it's trajectory at any time is the same. Mathematically it can be formulated as follows.

$$E_{M_1} = E_{M_2} \tag{5}$$

$$E_{P_1} + E_{K_1} = E_{P_2} + E_{K_2} \tag{6}$$

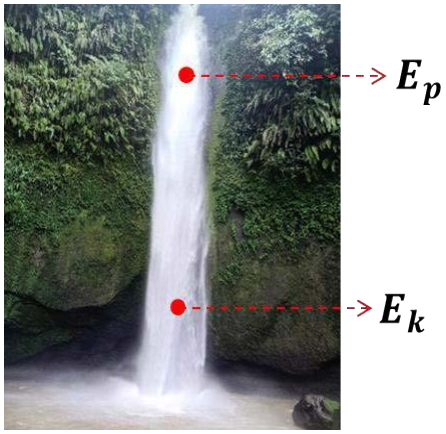


Figure-3. Potential Energy and Kinetic Energy in a Waterfall

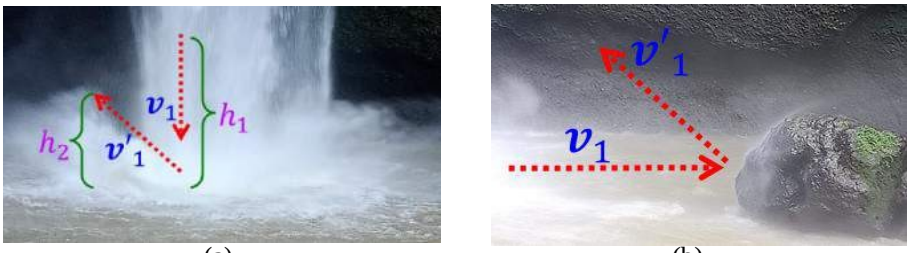
4. Momentum and Collisions

The momentum of an object is defined as the product of it's mass and velocity. (Giancolli, 2014). The particles from a waterfall have a large momentum, because when the falling water particles move at a very large speed, as a result of the greater momentum of waterfall particles, the more difficult is it to stop it and the impact of what is given when water particles collide with the ground, a hole will be formed besides that when the collision of water particles with the surface of the plunge pool causes water particles to scatter. The collision between water and the surface of the plunge pool is a partial collision. Mathematically it can be written.

$$\boldsymbol{p} = m\boldsymbol{v} \tag{7}$$

$$\boldsymbol{e} = -\frac{\boldsymbol{v}_2' - \boldsymbol{v}_1'}{\boldsymbol{v}_2 - \boldsymbol{v}_1} \tag{8}$$

$$e = \sqrt{\frac{h_2}{h_1}} \quad \text{where } 0 < e < 1 \qquad (9)$$



(a) (b)

Figure-4. (a) collision between the falling water and the plunge pool surface; (b) collision between water particles and stones

5. Friction Force

Friction is a force that occurs between two objects that touch each other. (Hardiansyah, 2021). Friction events can be observed when water falls, where the water looks white caused by air friction with the water particles as in Figure-5.

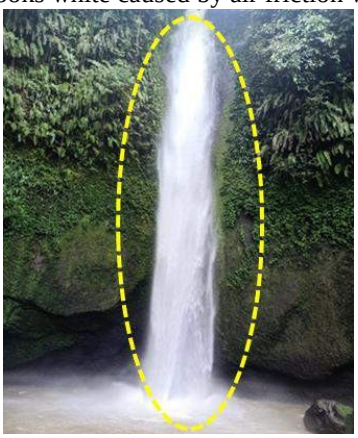


Figure-5. Friction between water particles and air.

Air friction occurs due to the deflection of air by the shape of the object. 9Abdullah, 2017). Air friction can be mathematically written as follows.

$$F = \frac{1}{2} C_D \rho_u A_p v^2 \qquad (10)$$

Where: C_D = coefficient of friction; ρ_u = density of air; v = relative rate of the object to the air; dan A_p = projection of the object area on the direction of air flow.

Utilization of the natural attractions of tumimperas waterfall as a learning center, can encourage students to reconstruct their knowledge through learning expiriences visiting tourists sites in TED-L activities. By carrying out exploration activities on the concepts of physics through observation of existing facts, issues, and phenomena. Throught exploration activities participants can learn to think at a high level. In line with the results of research done by Mgoryanto, W. M. (2020) in exploration activities also stated that exploration activities can provide a new learning atmosphere so that it can increase learning initiative and motivation. In addition, exploratory learning can improve students higher order thinking skills.

CONCLUSION

The results of the identification of physics concepts that has been done at the tumimperas waterfall in Thematic-Explorative-Democratic Learning (TED) in exploratory activities, can be identified a few physics concepts, namely

Parabolic Motion, Mechanical Energy, Momentum, Collision, and Friction. The concept of parabolic motion is shown in the trajectory formed when the water falls of the cliff, where in the vertical direction the waterfall particles undergo a change in speed while in the horizontal direction the speed of the object is constant. The concept of mechanical energy shows that the amount of mechanical energy at each point in the waterfall is the same. Furthermore, the physics concepts that are observed is the concepts of Momentum and Collision. In the concept of momentum, it is explained that the momentum of an object depends on the velocity of the object, and the occurring collision between the falling water and the surface of the waterfall is a partial collision. The next concept is the concept of friction which shows that air friction with water particles causes white causes white water particles. Based on the results of the research, it can be stated that the tourist attraction can be an educational center, especially in learning Physics.

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