Experiments of the law of conservation of mechanical energy using video tracker in high school learning

S A Fahrunnisa*, Y Rismawati, P Sinaga and D Rusdiana
Departemen Fisika, Universitas Pendidikan Indonesia, Jl. Dr. Setiabudi No. 229, Bandung 40154, Indonesia

*syifafahrunnisa@gmail.com

Abstract. Props have been made to prove the law of conservation of mechanical energy using a video tracker, a miniature road Roller Coaster is a teaching aid that will be used for experiments. Through this learning media, it is hoped that it can help the physics learning process of Covid-19. The learning implementation is carried out in one of the high schools in West Bandung Regency in the even semester of the 2019/2020 school year. Determination of the research area using the method of the purposive sampling area, which means the area was chosen deliberately based on specific objectives and considerations. The population in this study were all students of class X MIPA. Using a video tracker is very helpful in the experiential process, the results of the implementation of this learning media can be implemented well as indicated by the results of the achievement of student indicators.

1. Introduction
Experiments are experiments to prove a particular question or hypothesis, experiments can be done in the laboratory or outside the laboratory [1]. With the experimental method, students can conduct experiments to find evidence of the truth of a theory that is being studied. Experiments need to be applied in schools, so students not only understand the theory but students prove the truth of the theory. Through the method of experimentation, students are involved in doing themselves, proving, and drawing their conclusions about an object, situation, or certain process [2]. Experiments have an important function for students, namely, being able to find and find their answers to the problems they face by conducting their experiments. Experiments will make students actively experience, understand, and prove themselves what is being learned. Experiments train students to find factual data obtained through observations and not opinion data from students' thoughts, so students are trained to draw conclusions based on observational data. Learning by the experimental method will be more effective if there are space and time for teachers and students to plan experiments, discuss ideas, critically record, and analyze observations [3]. Physics is one of the subjects that must be done experimentally, so you cannot rely solely on writing. Physics is a method for seeing the universe, understanding how the universe works, and how the parts in it relate to each other. Physics equations state the relationship between physical concepts by using symbols that represent physics concepts [5]. Things like this that make physics learning must be done by involving experiments in it.

However, the experimental method has constraints, including: a) need a lot of tools and costs b) requires a relatively long time c) very few schools have experimental facilities [6]. Added to the current situation, experiments in the laboratory (school) cannot be carried out due to having to implement physical distancing. About the Prevention of Corona Virus Disease (COVID-19) in the
Education Unit which states that dismiss schools and colleges [7]. So that teaching and learning activities in schools must be stopped. The arrival of the Covid-19 epidemic was very sudden, so the Indonesian education world needed to follow a path that could help the condition of schools, schools need to force themselves to use online media [8]. Students do not need to study at school but study at their own homes.

Through the use of technology, the learning process becomes time-saving, free of geographical barriers, improves the quality of experiments, increases the effectiveness of learning, and increases security [9]. Excavation of physics concepts through activity analysis can be done with the help of technology which consists of physics-based video analysis, for example, tracers, the software is feasible to use with a very good predicate to analyze motion kinematics video [10]. Tracker Software that allows students to research terms of kinematics comprehensively. This software through a video analysis method about natural events, especially those related to speed, speed, acceleration, force, gravitational field, energy conversion, and conservation [11]. A tracker is a freeware software designed to be used as a video data input that transfers images about the motion of objects and has been widely applied in physics education to be implemented and simulates physical phenomena in mechanics. [12] Video tracker analysis offers several opportunities for discussion and complete measurements found students like the camera on [13] Tracker is a device used as input data of video images of moving objects to analyze and model phenomena. In previous studies that the Software Tracker has a very high truth to determine the acceleration of completion (g) of the earth because of the way tracking is done can use 2 ways, namely manual or automatic [14].

Problems that arise based on constraints in the implementation of the experiment, the type of experiment that can be done using the tracker software as a tool, with equipment and materials that are easy to find and cheap and easy to do. The video tracker technique can be useful for students, because students have the opportunity to be trained in the process of taking fact data, in identifying the relationship between physical quantities. The important purpose of simulations is to replace expensive experiments. In this case the video tracker can be very useful in high schools and universities with low budgets.

2. Methods
A tracker is a software that can be used to analyze the motion video of an object [14]. As shown in Figure 1, we chose the material of the law of conservation of mechanical energy to prove the theory of conservation of mechanical energy. One example of its application to the Roller Coaster road begins with the miniature design of the Roller Coaster road. Then the first step in making tools is to compile and make a Roller Coaster path using the materials that have been provided. The method used in this study is the experimental method, all the steps of the experiment were videotaped. The first step in data collection is to prepare tools and materials to be used in the practicum, then prepare a toy car, measure the mass of the toy car mass and the height at each point then launch the car from the starting point to the endpoint. The results of the experimental video were analyzed using the tracker application, the video tracker function as input data to be analyzed by the tracker application. This is software that is used as input data of video images of moving objects to analyze and model phenomena [11]. Before recording the phenomenon students can observe and repeat experimenting as needed, and then they can make recorded images, video image data can be interpreted as "frozen phenomena" [15]. In this experiment, the video tracker that will be analyzed is the speed of the car at each predetermined point. The procedure of motion analysis with the video tracker is as follows: 1) Upload / Import video in the tracker 2) Set frame 3) Calibrate the stick 4) Set the x-axis and y-axis 5) Determine the point of time and displacement to find out the speed of the toy car 6) Analyze the moving objects with the auto track command. After the data is obtained and then we make a learning video about the explanation of the law of conservation of mechanical energy.
After the video tracker has been analyzed and obtained the following data, we package the experiment into a learning video. So that learning can be done through online media, then the learning video is implemented through online media using WhatsApp Group, video and LKPD shared in the form of Ms. Word to all MIPA grade X students in one of West Bandung Regency High Schools in the even semester of the 2019/2020 school year.

3. Result and Discussion

3.1. Figure

Based on the tool scheme in Figure 2 the mechanical energy of the roller coaster is influenced not only by the position or state of the track but also by the frictional force. Schema Figure 2 note that the value of mechanical energy at position A is the same as mechanical energy at position B.

\[ EM_A = EM_B \] (1)

While the kinetic energy in A is zero and the value of potential energy in B is also zero so the value of potential energy in A is the same as the kinetic energy in B.

\[ EP_A = Ek_B \] (2)
This research is using the experimental method, experiments in measuring the speed of toy cars are carried out by launching toy cars from the highest point (point A) to the lowest point (point B). The value of mechanical energy at position A is the same as mechanical energy at position B and the kinetic energy at A is zero while the potential energy value at B is also zero so the potential energy value at A is the same as the kinetic energy at B.

3.2. Results

Based on Figure 3 shows the results of the data based on the video tracker, in this data the velocity value is directly obtained because in the tracker application we have set the necessary variables namely displacement and time.

![Figure 3. Velocity when the car is at point A, based on the results of Fig. 3 that the car's velocity at point A is 0 m/s, because at point A the car is at rest. In figure 3 you can see the velocity data table has no value.](image)

The results of the data obtained next are the velocity of the car at point B, C, D shown by Figure 4

![Figure 4. The velocity at the time of the car is at point B based on the results of the car velocity tracker 2.422 m/s, while at the time of the car at point C the velocity is 1.620 m/s, and for the velocity of the car at point D the velocity is 3.741 m/s.](image)

The first tracker table is the velocity of the car at point D, then the velocity at point C, the velocity decreases because the track goes up to point C, while at point D the results of the data are obtained at an increase.

3.3. Table

Table 1 shows the results of experimental data with a tracker application to prove the theory of conservation of mechanical energy and shows the mechanical energy values at each point \( E_{MA} = E_{MB} = E_{MC} = E_{MD} \).
Table 1. Table of experimental data results in the height table is measured using a ruler while at the speed of using the tracker application

| Mass (kg) | The position of objects | Height (m) | Velocity (m/s) | Ep (Joule) | Ek (Joule) | EM (Joule) |
|----------|-------------------------|------------|----------------|------------|------------|------------|
| 0,05     | A                       | 0,7        | 0              | 0,343      | 0          | 0,343      |
|          | B                       | 0,4        | 2,422          | 0,196      | 0,147      | 0,343      |
|          | C                       | 0,5        | 1,628          | 0,245      | 0,0663     | 0,3113     |
|          | D                       | 0          | 3,741          | 0          | 0,349      | 0,349      |

The amount of $E_k + E_p$ at point A and point B is the same, but at points C and D there is a slight difference, but it still tends to remain. This could be due to the friction between the cars with the track, causing the object to be inaccurate speed.

Table 2 explains the indicators' consideration of understanding students by seeing the results of the percentage of true and false numbers when students answer questions on the worksheet. This result is obtained based on the application of the video contained in the video, which is a mechanical energy conservation practicum law with a miniature roller coaster road conducted on class X students.

Table 2. Analysis of student understanding achievements

| No. | Student Understanding Indicators                                           | Maximum Score | Number of Students Answering | Percentage of Students Answering |
|-----|---------------------------------------------------------------------------|---------------|------------------------------|----------------------------------|
| 1   | Interpret experimental data into tabular data                            | 8             | 26                           | 100%                             |
| 2   | Explain the energy magnitude and potential at each point                 | 6             | 26                           | 100%                             |
| 3   | Explain the relationship of potential energy with changes in the position of objects | 2             | 11                           | 42,31% 57,69%                   |
| 4   | Explain the relationship of kinetic energy with changes in the position of objects | 2             | 5                            | 19,23% 80,77%                   |
| 5   | Explain the relationship of kinetic energy to potential energy           | 2             | 12                           | 45,15% 53,85%                   |
| 6   | Determine the results of the sum of potential energy and kinetic energy   | 8             | 26                           | 100%                             |
| 7   | Explain the relationship of $E_p + E_k$ with the position of objects      | 2             | 7                            | 26,92% 73,08%                   |
| 8   | State the results of the sum of potential energy and kinetic energy       | 2             | 26                           | 100%                             |
| 9   | Comparing the amount of mechanical energy at each point                  | 2             | 5                            | 19,23% 80,77%                   |
| 10  | Summing up the results of an experiment                                  | 6             | 24                           | 92,31% 7,69%                    |

The results of student implementation can interpret experimental data into tabular data and explain the magnitude and potential energy at each point by using the visualization of the mechanical energy conservation law trial, shown by an excellent percentage of questions number 1 and 2. Item number 3, 4, and 5 the results of the percentage are not good because students have not been able to explain the relationship of potential energy and kinetic energy with changes in the position of the object, this is
because students are considered to understand the concept of potential energy and kinetic energy so that at the beginning of the video is not explained. Determine and mention the results of the sum of potential energy and kinetic energy of highly capable students, it can be seen that presentations on questions numbers 6 and 8 reach 100%. The percentage in question number 7 shows students are less able to explain Ep + Ek to the position of objects, as well as number 9 students are not able to compare the amount of mechanical energy at each point. Although by using video experiments students can deduce the results of the experiment properly and correctly, this is evidenced by the acquisition of item number 10.

4. Conclusion
Experiments using this video tracker software analysis can be applied to a variety of physics-based physics experiments, so that the mechanical energy conservation law experiments can be proven, by proving an experiment it will help students understand the concepts of physics. The implementation of experiments using a video tracker packaged into learning videos delivered online can be done well, greatly helping the learning process in the Covid-19 era. While the success of achieving indicators of understanding students' concepts are not all achieved well.

5. References
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