USING CAR TOYS WITH VIDEOS TO INTRODUCE KINEMATICS IN PHYSICS

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Abstract. This research aims to describe the use of car toys with Videos (TvW) in introducing Kinematics. This research specifically also provides information on the advantages and disadvantages of using TvW in learning Physics. This research was conducted at the Indonesia Railway Academy (IRA) - Madiun in the railway transportation management program, taking Physics classes A and B (46 students). A pre-test and a post-test of the concept of kinematics were given to determine the influence of TvW. It can be concluded that the use of TvW increases the kinematics conception test scores with N-Gain (0.44). The weaknesses in the TvW media can stimulate the emergence of the cognitive conflict and higher order thinking skills in which the students are required to discuss the causes of the incompatibility of experimental results with the theory.

1. Introduction

Physics learning will be more meaningful if students can find their physics concepts [1,2]. The inquiry is one of the learning models that direct students to discover physical concepts [3–5], both in having a discussion and doing an experiment. Experimental activities in Physics can be done in two ways (1) finding through mathematical simulations, (2) through real [3,6–8] experiments [3,6–8]. Mathematical simulation activities require the ability to interpret equations and graphs, while experiments tend to strengthen understanding of basic concepts. In learning at Indonesian Railway Academy (IRA), it was found that students did not understand the concept of constant speed in kinematics learning. In addition to a lack of mathematical understanding, initial knowledge about position, distance, and displacement was not understood by the students. The representation of concepts in the mathematical form with indirect measurements is needed to strengthen students' understanding of the concept of kinematics. The way that can be done is through experimental activities. Through experimental activities, concepts and relationships between concepts are introduced to students.

Physics is a subject that the students must take at the IRA. In the learning of Physics, students were taught through experimental and face-to-face activities. Experimental activities were carried out at partner campuses given the limited facilities owned by our campus, especially the basics of science. Effective ways are needed to overcome this problem, one of them is using media through experimental activities. This article describes the use of toys with video (TvW) to teach the concepts of Physics, especially kinematics. Previous studies have described that Physics can be found everywhere, for
example in the kitchen [9], dining table [10], games [11,12] and the traditional games [13]. These results reinforce that teaching physics does not require sophisticated and expensive tools. Development of research with simple and sophisticated tools has also been carried out in previous research [14–17], where research using simple tools can replace expensive physical experimental tools. However, sophisticated tools still have better accuracy than others. Both of these tools require time in making them. Effective experimental tools are needed in preparation and use. This article describes the use of TwV which can provide an initial understanding of kinematics concepts to the students.

2. Method
The method used in this research is descriptive, by presenting information about the design, implementation, and evaluation of TwV usage in learning. A pre-test and a post-test were given to students using kinematics concept tests that have been developed in previous research [18]. The research sample was students of the Transportation Management Program of IRA who took Physics in classes A and B (46 students). Before and after learning, students were given a pre- and a post-test to determine the score of their understanding of the concept. The N-Gain [19] was used to determine the category of the improvement in student conception test scores.

3. Results And Discussion
3.1 Design
TwV is designed according to the material to be discussed. Experiments were carried out to analyze (1) motion with constant velocity and acceleration, (2) gravitational acceleration. The experimental steps are described in Table 1.

Table 1. Experimental Steps

| Subject                          | Experimental Steps                                                                 |
|---------------------------------|-----------------------------------------------------------------------------------|
| Motion with constant velocity   | 1. Arranging car toys and cameras according to the following design (fig. 1):     |
| and acceleration                | Fig 1. Car toy track design                                                       |
|                                 | The camera must be able to capture the car's motion for at least 3 seconds.       |
|                                 | 2. Transferring video results to a laptop, then take photos of 4-5 car toy positions using the video editor software on the laptop every 1 ms or adjust as long as periodic. |
|                                 | 3. Making a graph ($\Delta x$) versus ($\Delta t$). The distance of a car toy can be determined by using the design software. |
|                                 | 4. Interpreting $\Delta x$ versus $\Delta t$.                                    |
| Gravity acceleration            | 5. Describing and concluding the motion of a car toy.                             |
|                                 | 1. Dropping the object from a height of 2-5 m, placing the camera so that it can record the motion of the ball (Fig. 2). In this second lesson, video files are provided by the lecturer to make time effective. |

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Fig 1. Car toy track design

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**Subject** | **Experimental Steps**
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**Fig. 2** Dropping objects

2. Transferring the video results to a laptop, then taking photos of 4-5 object positions using the video editor software on the laptop every 1 ms or adjust as long as periodic.
3. Making a graph $(\Delta y)$ versus $(\Delta t)$. The distance of the object can be determined by using the design software.
4. Interpreting $\Delta y$ versus $\Delta t$.
5. Describing and concluding the motion of the object.

### 3.2 Implementation and evaluation

In the implementation, student groups took and analyzed the data by the stages procedure in Table 1. The findings of difficulties in group work on problem 1 included: (1) there were 2 groups who took videos in a short time, so they needed to take videos once more, (2) The data generated from the interpretation of the images on the video are too few and this became one of the limitations in the use of this media, (3) all groups had not been able to analyze the graph using regression, (4) Low understanding of students’ concepts related to position, distance, movement, velocity and speed. This paper is limited to the discussion of kinematics concepts about speed. Problem number 3 was reduced by discussing the concept of position, distance, displacement, the magnitude of displacement and speed in face-to-face learning.

In addition to the problems that have been described, the software and hardware use also gave different results even though the data obtained could still be used to interpret the graph. The examples of video capture results are presented in Fig. 3 below:

Fig. 3a is an example of the interpretation of the graphs of the video analysis. Graphics interpretation provided information that the graph $\Delta x$ vs. $\Delta t$ produces a linear curve, which gives information that $\Delta x$ is perpendicular to $\Delta t$. This graph information gives initial knowledge that if $\Delta t$ approaches 0, then: $dx=C_1 \, dt+C_2$ which is the general equation of motion with constant velocity. If $C_2=0$, the equation becomes $dx=C_1 \, dt$ where $C_1$ is speed. The lecturer directed the students to find this equation, and stimulated them to find general equations of motion.

Fig. 3b also provides information that the car toy does not move at a constant speed or constant acceleration. It can be seen from the graph form $\Delta x$ vs. $\Delta t$ which is not completely linear. At the end of learning, students were asked to provide conclusions related to the description of the motion experienced by the toy and the relationship of the regression equation obtained with the equations in the textbook. These results provide information that the physical equations contained in textbooks, for example for straight motion with constant speed ($dx=v \, dt$) can be realized in an ideal state (in a laboratory). Initial information obtained from this activity is expected to assist students in describing the causes of nonconformities of the results of the experiment with the theory when practicing at partner institutions with standard tools. The information on the speed presented by the graph gradient $\Delta x$ vs. $\Delta t$ is not accurate, because it uses photo imaging and ignores the scale to identify position and distance.

On problem 2, the finding is concentrated on the incompatibility of the gravitational acceleration values of the experimental results and the theory. This discrepancy is caused by accuracy and error in measuring the position obtained from the photo. To increase the accuracy, other researchers
recommended using tracker [20], but students activity and discussion will decrease because there was no problem found. The example of the results of the presentation of pictures and graphs in fig. 4.

The graph interpretation results is strengthening the concept of gravitational acceleration towards the negative sign. During this time, students had a conception that the acceleration of gravity down has a positive sign. The findings of the negative gravitational acceleration were still found in three groups in the class. During the discussion process of the results of the analysis, the lecturer gave an understanding that acceleration is a vector quantity and the direction follows the agreement of the coordinate system used. Students were enthusiastic in responding to TwV usage. At the end of the learning, students were asked to give opinions on the use of TvW. All students asked for physics learning using media so that it was not boring. The N-Gain was used to determine the improvement in the test scores of the use of TvW conception (table 2).

| Class       | Average Pre-test score | Average Post-test score | N-Gain | Category |
|-------------|------------------------|-------------------------|--------|----------|
| Experiment  | 69.65                  | 82.96                   | 0.44   | Medium   |
| Control     | 68.96                  | 74.48                   | 0.17   | Low      |

Based on the results of N-Gain (Table 2) it was concluded that the use of TvW could increase the students’ score in the medium category (0.44), while in the control class it was in the low category (0.17). Based on these results, the use of TvW media in learning as an alternative limitation of experimental equipment is recommended to be used. The use of media in learning can help students understand abstract concepts. These results are consistent with the research [21]. The use of media can also attract attention and motivation of students in learning Physics [1,9,11–13,15] so that it has an impact on increasing the score of conception and learning achievement.

4. Conclusions
Based on the results and discussion that have been described, it can be concluded that the use of TvW can increase the score of kinematics concept in the medium category (0.44). Physics learning at the Indonesian Railway Academy needs to consider ICT-based media as an alternative to the limitations of experimental equipment in the laboratory. Learning activities with TvW media are more effective regarding time than face to face learning. The weakness of TvW is related to the suitability of the experimental results with the theory, but it is representative to link the relationships between Physical concepts. The weaknesses in the TvW media can stimulate cognitive conflict and higher order thinking skills of the students. Although TvW media can improve the conception test scores, laboratory equipment that has a higher level of accuracy needs to be introduced to students to strengthen their conception.

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