Fluid experiment design using video tracker and ultrasonic sensor devices to improve understanding of viscosity concept

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Abstract. This study was a quasi-experimental study which aims to compare the increase in understanding of the concept of viscosity in a group that were assisted by a video tracker, ultrasonic sensor devices and manual observation. This research was conducted on first semester students at a university in the city of Semarang. The data obtained in the form of qualitative data in the form of interviews and quantitative data in the form of learning outcomes measured using essay questions. Based on the analysis of data that the use of video tracker in experiments to determine the viscosity coefficient provides the highest increase in comparison compared to experiments using a magnetic sensor and manual observation. In addition, an experiment assisted video tracker provides students with science process skills and was more interesting than assisted experiments with ultrasonic sensors and manual observation.

1. Introduction

Physics is a lesson that explains various natural phenomena that often occur and can be studied with logical mathematical calculations or through experiments [1]. Physics experiments in learning are very helpful in understanding the material presented [2], one of which is the viscosity. Viscosity measurements can be done by several methods such as the method of falling ball, rolling ball, capillary pipe, cylindrical rotation of the cylinder, and plate cone rotation. Among these methods, the fall ball method is a method that is often used because of the simplicity of its measurement. However, this method has a disadvantage because the measurement of the fall time of the ball is very fast, therefore a precise and precise detector is needed to record the correct time. The progress of science and technology is inseparable from the progress of Physics, especially Electronics. One of them is the development of school laboratory equipment. In the use of this school laboratory equipment there are
still many that are manual, so that measurement data that is less accurate causes the results of the experiment to be obtained to have a fairly high error rate which in turn leads to misconceptions in students. Therefore, a method is needed that can minimize inaccuracies in measurement. One way is with the help of the tracker video analysis application.

Tracker video analysis is one application that can be used to help students learn various phenomena of two-dimensional motion. This application was developed by Java Open Source Physics (OSP) and has the ability to track the motion of an object so that various information can be obtained in the analysis of two-dimensional motion. Tracker video analysis can be used as an alternative in physics learning to analyze movements [3]. Through recording activities a real motion phenomenon using a video recorder (handycame), then the recording is processed in the Tracker Video Analysis application, so students can obtain various information such as the position of objects (x, y) at each time (t), so that it will provide convenience in the motion analysis process.

The use of tracker video analysis gives students an easy and simple way to observe various characteristics of motion and understand the processes of motion that occur as a basis for obtaining accurate data (reducing measurement errors) that are difficult to obtain by conventional experiment tools, while also providing understanding deeply related to graph representation presented at the same time as the phenomena analyzed [4]. The characteristics of tracker video analysis as an analysis of classical physics learning have been widely used in kinematic material such as solutions to resolve misconceptions that occur in students about free fall motion [5], cylindrical kinematics move down the inclined plane [6] bullet motion [7], and even analyze students' understanding of the concept of car braking distance [4]. In line with the development of computer-assisted OSP-based learning applications through this video analysis, we can draw a common thread between the development carried out in learning applications in line with the skills students must possess in the global information era, in terms of using video analysis in learning about motion [8]. The use of this media in learning significantly affects the level of student knowledge, for example in remembering, understanding, and active learning so that students in learning physics are more fun or happy.

Other problems in experiment are very limited time spent while in fact in experiment activities takes a long time. Therefore, another way that can be used in determining the viscosity coefficient with time is by using a viscometer. Viscometer is a tool used to determine the value of fluid viscosity. Viscosity is also called the level of viscosity of a liquid. Viscosity is a measure that states the thickness of a test liquid. Viscosity is nothing but the nature of a liquid which is very closely related to the resistance of a test liquid in flow [9].

But the price of a viscometer which is quite expensive causes the presence of a viscometer in the laboratory very rarely. Therefore, it is necessary to develop a tool that works in accordance with the working principle of a viscometer, but with small funds. One alternative is to use ultrasonic waves developed using Arduino Uno as a microcontroller to program the system [10]. Arduino Uno is a microcontroller chip that has been integrated with the microcontroller which is equipped with various features that provide convenience for users [11]. The use of Arduino has been widely applied in learning and physics experiments including the use of Arduino to investigate simple harmonic movements [12] and the use of Arduino in teaching the basics of photovoltaic cells in cell studies solar [13].

2. Methods
This research was conducted at the first semester physics education students at one of the universities in the city of Semarang. In experiment, all research subjects were divided into 3 categories of groups that would carried out practical activities with different methods, namely groups that use video tracker, ultrasonic sensor devices and without using both of them only use physics experiment set. Each category consists of 5 to 6 groups. Therefore the research design that can be applied was the design of three Solomon groups as described in table 1.
Table 1. Design of three groups by Solomon

| Group         | Pretes | Treatment | Postest |
|---------------|--------|-----------|---------|
| Experiment 1  | O₁     | X₁        | O₂      |
| Experiment 2  | O₁     | X₂        | O₂      |
| Experiment 3  | O₁     | X₃        | O₂      |

Where O₁ is objective test 1, O₂ is objective test 2, X₁ is first treatment (viscosity experiment with the help of tracker video analysis), X₂ is the second treatment (experimental viscosity with the help of ultrasonic sensor or digital viscometer), and X₃ is the third treatment (experiment viscosity without assisted by a tool or manually).

The data obtained from the results of this study are data on understanding the concept of student viscosity measured at the time before and after being given different treatments. Increasing the understanding of the concept of viscosity will be analyzed by using normalized gain.

3. Results and Discussion

Based on observation that the implementation of experiments with different situations has different effects. It was indicated by the presence of student responses when conducting interviews. Other than that, it can also be seen from the results of the final test that there is a difference in increasing the understanding of the concept of viscosity as shown by table and figure bellow. The results description of the pretest and posttest understanding of the concept of fluid viscosity can be seen in table 2.

Table 2. Pretest and Posttest Results Understanding the Concept of Fluid Viscosity

| Fluid Viscosity Experiment | Description          | Pretest | Posttest | N-Gain | Categories |
|----------------------------|----------------------|---------|----------|--------|------------|
| Video Tracker              | Average              | 36      | 76       | 0.63   | Middle     |
|                            | Standard deviation  | 0.54    | 0.89     |        |            |
| Ultrasonic sensor Devices  | Average              | 30      | 64       | 0.47   | Middle     |
|                            | Standard deviation  | 0.71    | 8.94     |        |            |
| Eksperimen Physics Set     | Average              | 35      | 72       | 0.56   | Middle     |
|                            | Standard deviation  | 0.84    | 0.98     |        |            |
Based on table 2 that the average pretest understanding of the concept of fluid viscosity in students using video tracker is 36, the average posttest understanding of the concept of fluid viscosity in students using video tracker is 76. Increased understanding of the concept of students using video tracker is 0.63 including the medium category for improving the understanding of fluid viscosity concepts in experiment student groups with the help of video tracker. This is caused by several factors, including that students feel easier in determining the relationship between the variables that affect the value of the viscosity of a substance through the data displayed by the video tracker software in the form of numbers and graphics. In addition, students are also trained in other skills such as skills on how to interpret graphics, how to use the camera to get videos of good quality and how to use the video tracker application to analyze videos. Another thing that can be seen from the experiment is assisted by a video tracker in measuring the viscosity of a substance besides providing students with process skills but also providing precise data so that there is very little chance of misinterpretation that triggers misconceptions [14].

Increasing the understanding of students' concepts using ultrasonic sensors is 0.47 including the medium category for increasing the concept of fluid viscosity in the experiment student group using Arduino with the help of ultrasonic rays. The average pretest understanding of the concept of fluid viscosity in students using Physics experiment set is 35, the average posttest understanding of the concept of fluid viscosity in students using Physics experiment set is 72. Increased understanding of students' concepts using Physics experiment set is 0.56 including the moderate category and the lowest understanding of concepts from the three types of experimental groups. This happens because students find it difficult to understand the relationship between variables that affect the value of the viscosity of a substance. Although the data produced from measurements using ultrasonic sensor devices is very precise, the final value and time required for the experiment are very efficient, but students still feel confused about the concept of viscosity, which causes a low understanding of the concept of viscosity. In addition, in a trial assisted ultrasonic sensor devices did not equip process skills with students because the final results of the experiments were automatically read on the screen of the sensor device.

The manual viscosity experiment without the help of a video tracker and Arduino device as shown figure 3 that provides understanding of concepts and good science process skills to students because manual measurements that only use set experiments have become the routine of students in taking physical experiment data. However, in this lab the students experienced problems in the accuracy of the timers and distance meters that were less accurate. Inaccurate data causes errors when interpreting the relationship between variables that affect the viscosity value of a substance so that there are some misconceptions that result in an increase in understanding of concepts that are quite low in the three groups. Also, it can be seen in table 2 that the average pretest understanding of the concept of fluid viscosity in students without video tracker and Arduino devices is 35, the average posttest understanding of the concept of fluid viscosity in students using Physics experiment set is 72. Increased understanding of the concept of students using Physics experiment set is 0.56 including the medium category. To overcome these problems, video tracker analysis software is needed to facilitate students in experimental activities by analyzing experimental results in the form of videos and maximizing student involvement so that students can be more active in the learning process that prioritizes activities, where students are required to experience firsthand and find themselves sciences [7].
Based on Figures 4, 5, and 6 shows that the comparison of N-Gain conceptual understanding of students in the fluid viscosity experiment the highest understanding of concepts is in the group of students who experiment with the help of a video tracker. This is due to the use of video tracker in data retrieval at the time of experiment is very helpful for students in providing accurate data presented in the form of numbers and graphs so that it is easier for students to analyze and calculate the viscosity value of a substance. This is consistent with what was revealed by Yuniarti et al [15] that the use of video tracker is very effective in increasing the understanding of the concept of viscosity. This is because taking experiment videos provides an attraction and fun activities for students. And also, the use of a video tracker is able to train the soft skills of students, one of them is the ability of students to think creatively [16], namely how students are directed to be able to interpret the graphics produced by video analysis. In addition, the video tracker software makes it easy for students to analyze experiment results through displayed data and graphs so that the results obtained are more precise [17], and it might be an innovative and effective method for learning and teaching [18-21].

4. Conclusion
Based on the results of fluid viscosity experiment using video tracker, ultrasonic sensors devices, and Fluid Viscosity experiment set, it can be concluded that based on the results of analysis of fluid viscosity experiment data for all kind of experiment are increased understanding of the concept in the medium category. But the highest increased is experiment using video tracker because makes it easy for students to analyze experiment results through displayed data and graphs. But however the use of ultrasonic sensor devices is suitable for confirming the correctness of the data in determining the coefficient of viscosity. Therefore, physics learning espessially in kinematics experiment such as viskosity experiment will be more interesting if the three types of experiments are collaborated.
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