Exploration of student’s understanding of distance and displacement concept

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Abstract. This study aims to explore students’ understanding of the kinematics, especially in the concepts of distance and displacement. This survey research involved 21 first-year physics students that registered in the odd semester of the 2019-2020 Physics Education Program at Universitas Kanjuruhan Malang. Justification of students' understanding of kinematics concept is done by analyzing their responses to multiple choice questions, evaluating their arguments in answering the test items, and also through a series of individual interviews. With a mixed-method approach, the data are analyzed quantitatively and simultaneously as well as qualitatively. The result shows that about 42.8% of new students 2019-2020 understanding of displacement and distance concept, and the other have shallow understandings and even misconceptions.

Exploration of understanding the concepts of distance and displacement can be used as reference material and consideration for educators to develop appropriate, measurable, and efficient learning strategies.

1. Introduction

Investigation to understand and know students' initial understanding of a concept to be learned in the learning process is the initial step of an educator to develop appropriate and measurable learning strategies. The results of the investigation of student understanding can be used as a basis for curriculum development and as a consideration for teachers to determine the teaching methods used in the learning process [1]. Knowledge about students' understanding and students' difficulties with a concept will reduce the problems that arise in the learning process [2]. Students 'shallow understanding, or students' mistakes in understanding one concept in physics will affect the level of understanding of other interrelated physics concepts. Especially understanding of fundamental concepts, such as kinematics that explains the concepts of displacement, distance, speed, and acceleration. Students' understanding of the kinematics concept, for example acceleration will affect their understanding of the concept of mechanics. Because of the concept of mechanics, acceleration is a basic and very important concept [3].

Educational research continues to be developed, for example about critical thinking [4,5], creativity [6], and mastery of concepts [7,8], and the other. Furthermore, research to investigate students' understanding and difficulties with kinematics concepts has been conducted for the past 4 decades. The results of these studies indicate that students' understanding of kinematics is still shallow and tends to be wrong, among others: many students do not have a qualitative understanding of acceleration as the
ratio of $\Delta v/\Delta t$ [9], they often misinterpret the concept of acceleration in various circumstances [10], students have low ability to interpret graphs on the kinematics concept [11], students have difficulty analyzing the direction of acceleration due to changes in speed in the case of the moon around the earth [12], students still do not understand that momentary velocity is always in contact with the trajectory and cannot distinguish between acceleration and velocity [13], students understand that vector addition (eg in the case of velocity) can be done if the vectors have the same direction, students still have difficulty in reading and understanding graphic information on kinematics, especially understanding slope, negative slope in kinematic [14-20] students experience difficulty in m represents problems with images or in other different forms of representation [21]. However, research and inquiry into student understanding, student difficulties must be carried out by experts and educators continue to add and strengthen the results of previous research. Although research and investigation to determine students' understanding and difficulties with kinematics is not easy to do [22].

This study investigates students' understanding of displacement, distance, speed, and acceleration, but this article only discusses displacement and distance. Questions to be answered through this research include the following: 1) How do students 'understanding of distance and displacement?, 2) What are the students' arguments in answering the problem of distance and displacement?, 3) What misconceptions do students experience in the concepts of distance and displacement?

2. Methods
This research used mixed-methods approach and conducted in October 2019, at the Physics Education Study Program Kanjuruhan University Malang Academic Year 2019-2020. Research subjects were 21 first semester students who took the fundamental physics course 1.
students' responses during a brief interview. Students' arguments for answering test items and students' responses in short interviews of about 5-10 minutes each student are used to reveal students' understanding in a more original and in-depth way. To analyze students' understanding of kinematics, students are asked to solve problems in the form of written tests on the grounds and conduct a brief interview about the problem being solved. Based on the answers accompanied by the reasons on the test sheet and the results of each student's interview, it can be seen the students' initial understanding of kinematics.

3. Results and discussion

The first stage to determine students 'initial understanding is to analyze students' responses to the problems presented. The distribution of student responses for each test item is shown in table 1. Table 1 shows the number of percentages of students who answered correctly on each question. Students answered correctly in question 1 reaching 42.86%, question 2 about 38.1%, question 3 around 23.81, and no one student answered correctly on item 4.

| Item test | Students response (%) |
|-----------|-----------------------|
| A | B | C | D | E |
| 1 | 4.76 | 9.52 | 33.33 | 42.86 | 14.29 |
| 2 | 28.57 | 14.29 | 38.1 | 9.52 | 9.52 |
| 3 | 14.29 | 14.29 | 23.81 | 28.57 | 19.05 |
| 4 | 0 | 14.29 | 14.29 | 14.29 | 57.14 |

* correct answer

In the first item, students choose the correct answer numbering nine students around 42.86%. But from the analysis of student arguments in answering the problem and interviews, only six students used the correct displacement and distance concepts. they are able to answer correctly and provide arguments based on the correct concepts of distance and displacement (Figure 2), and while the other three students delivered inappropriate arguments, they equate displacement with distance then the distance or displacement can change longer or shorter according to changes in speed. So even though their answers are correct, the arguments conveyed through written answers or interviews show that three of these students have a misunderstanding and are very shallow understanding of the concepts of distance and displacement.

A short interview excerpt from one of the students with strong arguments is as follows:

**Interviewer**: Do you know the difference between distance and displacement?

**Student**: Yes of course, Displacement is position change during some time, and Distance is the length of a path followed by an object.

**Interviewer**: your answer at the first item test is the displacement is smaller or same with the distance traveled. So... what your reason?

**Student**: *(students sketch like the answer in the first item)* for example, a car moves through a straight line from point A to B then this displacement will always be the same as the distance of the track traveled *(then students write \( \Delta X_{A\rightarrow B} = d \)). But if the car is moving with a path that is not straight, such as zig-zag tracks or the other, when compared between displacement and distance, then the displacement will always be smaller than the distance *(then students write \( \Delta X_{A\rightarrow B} < d \)), so, it's clear that displacement is smaller or same with the distance traveled \( (\Delta X_{A\rightarrow B} \leq d) \).

From a short interview, it can be known that students use the conception of “Displacement is defined as the change in position during some time interval \( (\Delta X = X_{\text{final}} - X_{\text{initial}}) \), and Distance is the length of a path followed by a particle”. Student behavior above starts from a conceptual understanding of physical situations, and then provides quantitative solutions, and according to Tuminaro and Redish [23] identified as Mapping meaning to mathematics.
Figure 2. Examples of the arguments of students who chose answer D in test item 1.

The percentage of the next largest number of the first question item is choice C reached 7 people around 33.33%. Students choosing these answers express their own conceptions that cars or particles always move straight. This understanding has caused errors in making conclusions about distance and displacement used in solving problems in the first test item, as shown in Figure 3.

Figure 3. Examples of the arguments of students who chose answer C in test item 1.

A short interview excerpt from one of the students who chose the "always the same" answer is as follows:

Interviewer: why do you think that the displacement is always the same as the distance traveled?
Student: like this sir...(students are drawing like the answer in the first item), if the car moves from point A to point B (students draw a straight line connecting points A and B) then the displacement will always be the same as the distance (the student writes \( X_{AB} = S_{AB} \)).

Interviewer: what if the car is not moving straight, for example following a trajectory in the form of sine waves?
Student: hmmm... (just silent)
Interviewer: Do you know the difference between distance and displacement?
Student: yes sir, change position from one point to another during a certain time interval, and Distance is the length of a path followed by particle.

Based on a short interview excerpt with students who chose answer C, it can be concluded that some of them understand the difference between the concept of displacement and distance. But in solving the problem in the first item, they think that the car is only moving straight from A to B, without thinking about the possibility of another path like curves. Students actually have access to the right knowledge, but still ignore other knowledge needed to solve the problems in item 1 properly and correctly.

4. Conclusion
Investigation of students' understanding of the concept of kinematics especially the concept of distance and displacement is very important, because it will influence the further understanding of the concepts of speed, acceleration, vectors and even mechanics. Based on the results and discussion it can be concluded that students with a correct and strong understanding of distance and displacement are very few. Most of students confused the concept of distance and displacement, they assumed that there is no difference between distance and displacement.

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