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Using graphical presentation to reveals the student's conception of kinematics

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Abstract. This research aims to reveal and evaluate student conceptions of kinematics using graphical presentation. Students' conceptions can be expressed using graphic presentations and evaluations by providing feedback. Group discussions are also used to reduce misconception. The sample of this research is Physics Education Student Semester I (12 students) of PGRI Madiun University and Electrical Engineering Students of Class A and B (24 and 21 students) of Indonesian Railway Academy (API Madiun) which is taking basic physics. This research is qualitative descriptive research by describing the treatment before and after giving feedback, and discussion. Obtained information that (1) graphical presentation can provide preliminary information about student conception, (2) feedback and discussion can increase the percentage of students response. The recommendation of this finding is introducing mathematical language and graphics presentation before learning physics concept.

1. Introduction

Kinematics is a part of fundamental physics that is difficult to understand by the students [1,2]. This problem arises because the information presented in kinematics can be in the form of graphs and mathematical symbols [3–7]. Many students in high school and university level, are unable to understand the physics concept because of the limited ability to read and analysis graphics [8]. Students can solve mathematical problems related to algebra, but if the problem presented by graphical form, it is difficult for students to solve it. The problem becomes complex if the physical meaning of the physics symbols not yet known by the students.

In physics, mathematical equations and notations are used to represent the laws of physics, the expression of laws that are precise, concise, and solving problems [9]. The introduction of mathematical symbols is the first step that must do before introducing the physics concept. In high school level, presentations of mathematical concepts have been introduced, but are still practical to solve problems, and the students have not yet understood their physical meaning. The results of interviews with students provided information that at the high school level, presentation of mathematical concepts had introduced, but it was still practical to solve problems, and students had not understood their physical meaning.

Research on students conception of kinematics has been carried out [2,5–7,10,11], but there are only a few studies that reveal students' conceptions and difficulties in understanding graphic presentations [4,5,12,13]. Research on graphic presentations by physicists focuses on developing assessment such as modifying [14] and interpreting of graphics presentation [12], but not yet sufficient to express students' conceptions. It revealed by providing appropriate feedback. This article describes students' understanding of graphics presentations and problems that arise when students given that presentation. To reveal the student's conception of kinematics, the problems presented using graphs, sub-questions given in the form of feedback.

2. Method

This research describes students' conceptions of graphics presentations and problems that arise when students understand it. Sub-questions (feedback) are given to detect problems and levels of understanding that students have. Additional feedback is given by the lecturer to provide stimulus for students to reveal more in their understanding and to direct students to draw correct conclusions. This research conducted at two institutions in Indonesia, at the Madiun PGRI University and the Indonesian Railway Academy in the 2017 academic year. The samples of this study were students of Physics Education, and Electrical Railway engineering that took basic physics was 72 students. The steps of the research are as follows: (1) Students are given problems with graphical presentations with questions and sub-questions (feedback), (2) Students discuss in groups the problems and sub-problems given by the lecturer, (3) Additional feedback given if the sub-problems provided are not able to direct and reveal the problems given to students. N-Gain is used to find out the magnitude of the increase after giving discussion and feedback [15].

3. Results and Discussion

In the first step, The students are given problems with graphics presentations with questions and sub-questions. The Question with graphics presentations presented in the problem 1:
problem 1.

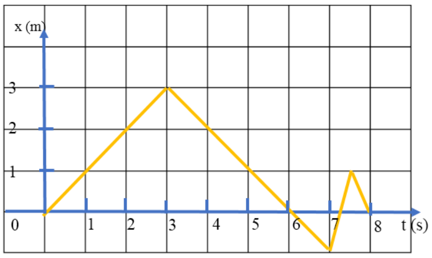

Figure 1. The relation between position (x) vs time (t)

Q1. Describe the motion of an object based on Fig.1!

Sub Q2 (feedback):

a. Determine the average velocity at t = 1s to t = 5s!
b. Based on Figure 1 above, determine the average velocity at t = 0s to t = 8s!
c. Determine the instantaneous velocity at t = 4s!
d. in what time condition the instantaneous velocity is zero?

The Student response categories for question 1 profiled in Table 1. Based on Table 1, students experience an increase in the percentage of response after being given the opportunity to discuss with peers and provide feedback. This increase in response caused by students getting information from colleagues and getting feedback from the lecturer. After discussion and giving feedback, complete and appropriate student responses have increased with N-Gain 0.33 (medium) for institutions A, 0.3 (medium) for B-1 institutions, and 0.24 (low) for B-2 institutions. Inappropriate/incomplete response with the category of N-Gain (low) found in two institutions. It can conclude that discussion and giving feedback can stimulate students to respond and lead to appropriate responses. These results are consistent with others research [16–18].The discrepancy of responses given by students can categorize into two, the students (1) understanding concept partially and (2) suspect misconceptions. Examples of student responses can be seen in Table 2.

Table 1. The Student responses of question 1

The Student Response Category	Before discussion	After discussion and feedback	N-Gain
Institution A			
Not giving a response	33.33%	0.00 %	-0.5
Giving a response, but not appropriate / incomplete	41.67%	50.00 %	0.143
Giving complete and appropriate response	25.00 %	50.00 %	0.33
Institution B-1			
Not giving a response	33.33 %	0.00 %	-0.5
Giving a response, but not appropriate / incomplete	50.00 %	58.33 %	0.167
Giving complete and appropriate response	16.67 %	41.67 %	0.3
Institution B-2			
Not giving a response	57.14 %	19.05 %	-0.89
Giving a response, but not appropriate / incomplete	42.86 %	57.14 %	0.25
Giving complete and appropriate response	0.00 %	23.81 %	0.24

Table 2. The Examples of student response descriptions

Category	Code	The student response
understanding concept partially	α	Question 1: The position of the object experiences rising, falling, going up, down and then stopping. Sub Question 1 Alternative 1: a. Time (t) = 1 s, average velocity (v) = 1 m / s Time (t) 5 s, average velocity (v) 5 m / s b. Time (t) = 0 s, then average velocity (v) = 0 m / s; Time (t) = 8 s then average velocity (v) = 0 s m / s c. instantaneous velocity (v) = 2 m / s d. Time (t) = 0 s and Time (t) = 8 s Alternative 2: a. time (t) = 1 s, average velocity (v) = 1 m / s time (t) = 5 s, average velocity (v) = 1/5 m / s b. average velocity= 0 m / s c. instantaneous velocity (v) ½ m / s d. Time (t) = 0 s and Time (t) = 8s
suspect misconceptions	β	Question 1 The velocity of objects going up, down, up, down. Sub Question 1 a. Time (t) = 1 s, velocity (v) = 1 m / s Time (t) = 5 s, velocity (v) = 1/5 m / s b. average velocity= 0 m / s c. instantaneous velocity (v) ½ m / s d. Time (t) = 0 s and Time (t) = 8s

Based on Table 2, it can see that students in the category α alternative one have the opportunity to experience (1) errors in reading graphic information, (2) not having the knowledge to read graphs. The indication is the student reading the gradient formed by x and t as a position. This response model found before students held discussions and were given feedback by the lecturer. The ability to read graphics is a basic ability that students must possess, considering the concepts in physics can be presented in mathematical and presented in graphical form. Giving a graphic presentation at the beginning of learning can help the lecturer in profiling the ability of students. the ability to read and interpret graphics is essential, so it is recommended to strengthen the understanding of mathematical language in physics learning [5].

Alternative response two also found in previous studies, where the contributing factor is that students do not have mathematical knowledge and connecting it to the concept of physics. Students partially understand the velocity equation because in response to the students' sub-questions ignore the mathematical symbols "Δ," "d" and vector symbol in completing the average and instantaneous velocity. The recommendation of this finding is to introduce and strengthen understanding of mathematical language [5].

In the β category, students recognize the term of velocity but assume that positive velocity has increases magnitude and negative velocity the opposite. At this stage, students response cannot conclude have misconceptions but are suspected of having misconceptions. The students are misconceptions when they are sure of their answer and assume that velocity and speed are the same meaning. Requires appropriate assessment to conclude that the student experienced misconceptions [19]. The results of the response analysis of students: (1) who experience misconceptions, and (2) others experience errors in reading graphic information.

The lecturer gave feedback based on the responses of students. Additional feedback is provided based on the response delivered by the student group. Examples of additional feedback questions are as follows: (2) Describe the definition of speed and velocity? (2) Write the form of speed and velocity equation? (3) What is the function of Δ", "d" and vector symbol in average and instantaneous velocity?, (4), and so on. Misconception will see from the way students write equations of velocity and speed, then perceive velocity and speed have the same meaning. If the conceptions of students are explored more deeply, a conception of distance and displacement will also have the same meaning. Environment, processes, learning resources at the previous level are one of the causes of this conception. Misconception is not discussed in depth in this article, only limited to suspects of misconception. Previous research provided more detailed definitions and procedures for identification of misconceptions[19,20].

Problem 2

Note the following Figure 2:

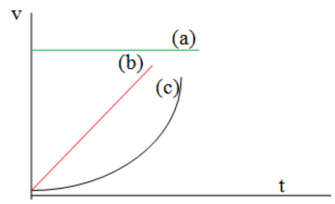

Figure 2. Relation graphs for speed vs time

Question 2

Based on Figure 2, if v is speed and t is time, the graph that represents acceleration in straight motion with constant speed is ..., Explain!

Sub question 2.

Speed and acceleration at t = 0 are ...

Student response categories to question 2 are described in Table 3. Based on Table 3, students provide increased responses after being given the opportunity to discuss with colleagues and provide feedback from lecturers in medium category (A=0.60, B1=0.40, B2=0.38). This question model found in many high schools. Many students give the right response to question 1, but there is an inappropriate response in the sub-question. Sub-questions are closely related to the ability to read graphs by presenting mathematical language information. Examples of student responses described in Table 4.

Table 3. Student responses to question 2

The Student Response Category	Before discussion	After discussion and feedback	N-Gain
Institution A			
Not giving a response	8.33 %	0.00 %	-0.09
Giving a response, but not appropriate / incomplete	33.33 %	16.67 %	-0.25
Giving complete and appropriate response	58.33 %	83.33 %	0.60
Institution B-1			
Not giving a response	0.00 %	0.00 %	0.00
Giving a response, but not appropriate / incomplete	41.67 %	25.00 %	-0.28
Giving complete and appropriate response	58.33 %	75. 00 %	0.40
Institution B-2			
Not giving a response	4.76 %	0.00 %	-0.05
Giving a response, but not appropriate / incomplete	57.14 %	38.09 %	-0.44
Giving complete and appropriate response	38.09 %	61.90 %	0.38

Table 4. The Examples of student response descriptions

Category	Code	The student response
understanding concept partially	α	Question 2 a, because the chart is straight, the speed does not change sub question 2 speed=0 m/s, acceleration=0 m/s^2 alternative: speed 0, acceleration cannot be defined
suspect misconceptions	β	Question 2 b, because the graph is straight, then speed does not change sub question 2 speed=0 m/s, acceleration=0 m/s^2

The α category is mostly due to the limited ability of students to read graphs. The choice of "a" is the appropriate answer, but the limitations of students in reading the graph can see in response to the sub-questions. If students understand the concept and can read graphs, the student will give a constant speed response, and acceleration = 0 m/s^2, but the response is not appropriate. It can conclude that students have little knowledge about concepts and limitations in reading graphic information. The β category in table 3 can arise because (1) students are wrong in reading charts, and (2) misconceptions. After feedback is given, the percentage change in the correct answer increases in both theα and β categories. Only a few students not change their conception because they do not have enough understanding about the differences in the concepts of speed and acceleration. The assumption of equalizing speed and acceleration arises because students mathematically see that acceleration and velocity are proportional to the equation, consequently, if the velocity is zero, then the acceleration is also zero. Previous research provides more detailed definitions and procedures for identifying misconception [19,21,22]. Question 2 provides information that many students have limitations in reading graphics.

4. Conclusion

The results and discussion direct the conclusion that there are still many students who have little knowledge of reading graphics, which has an impact on giving inappropriate responses. Many assessments are developed using graphics presentations but are limited to multiple choice forms, so they cannot reveal student conceptions well. Description of this research can be used as a basis for researchers to develop instruments with graphic presentations equipped with sub-questions that can explore student conception. Feedback is recommended to be given to reveal more about the conception that students have. Graphic presentations are also appropriate given in the learning process as a material for discussion in the learning process. Based on information in Table 2 and 4, obtained that the discussion process can increase the percentage of students in responding.

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