



K-10 Students' Conceptual Understanding of Linear Motion Concept: A Case Study

Ilma Husnah*, Muslim and Achmad Samsudin

Department of Physics Education, Universitas Pendidikan Indonesia, Bandung, Indonesia

*Corresponding author, E-mail: ilmahusnah@upi.edu

Abstract

Conceptual understanding is knowing more than isolated facts and methods. The effective students in physics learning must understand physics ideas and have the ability to transfer their knowledge into new situations and apply them to new contexts. Thus, students have the ability to find many alternative solutions to solve problems in physics learning. The study aims to obtain an overview of students' conceptual understanding of the linear-motion concept. A case study has been implemented through a single case, namely embedded design. The instrument charity in this research is multiple-choice. It was established after Anderson and Krathwohl's Taxonomy. The sample of this study involved 30 K-10 students, and their average age 15-16 years old. The test instrument contained six aspects in multiple-choice forms with a total of 15 questions and had a 'superior' unidimensionality (validity) measure. The result shows that the average student value was 42.89 (just about 38.42%) of the maximum score. In conclusion, students' conceptual understanding of linear motion is still diminutive; therefore, it is needed to develop conceptual understanding in K-10 students' context especially on linear motion concept.

Keywords: *Students' conceptual understanding, linear motion concepts, Case study*

1. Introduction

Founded on meticulous research about science, many students consider and said, "Physics is problematic". But, as Morales (2015) explored the views of high school students and physics teachers, he created the view that students discovery of physics is problematic because they have to struggle with different representations such as experiments, formulas and calculations, graphs, and conceptual explanations simultaneously. Moreover, in answering most of the physics problems, there is always a need for exemplification, so the students need to interpret problems into representational means first for them to understand what the problems in order to articulate them. For example, they are given a problem about force, so students need to interpret that problem into diagrammatic representations before going to mathematical representations discerning all the needed checks given in the question before answering the problem.

Students are assumed to understand when they are able to make sense from instructional messages counting verbal, written, and graphic illustrations, and material offered through lectures, in books, or on computer displays (Mayer, 2002). Students understand when they make connections between the new knowledge to be increased and their former knowledge (Sykes & Wu, 2017; Sickle & Friedrichsen, 2018). More specifically, the received knowledge is combined with current diagrams and cognitive frameworks (Ifenthaler, et al, 2011; Corredor, et al, 2014; Kadir, et al, 2018). When students understand physic concepts, they are able to solve problems and, when they see physics knowledge as a coherent web of ideas which applies to all walks of life, they can predict and explain various phenomena scientifically (Muis & Gierus, 2014; Ogilvie, 2009).

Conceptual understanding is knowing more than isolated facts and methods. Effective students in physics learning must understand physics and have the ability to transfer their knowledge into new situations and apply them to new contexts. Understanding is demonstrating comprehension through one or more forms of explanation (e.g., classify a mental illness, compare ritual practices in two different religions). Cognitive measures types of understanding including interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explaining (White, et al, 2011; Mortimer, et al, 2014; Karam & Krey, 2015; Nyléhn & Ødegaard, 2018). Appropriate learning outcome verbs for this level include: abstract, arrange, articulate, associate, categorize, clarify, classify, compare, compute, conclude, contrast, defend, diagram, differentiate, discuss, distinguish, estimate, exemplify, explain, extend, extrapolate, generalize, give examples of, illustrate, infer, interpolate, interpret, match, outline, paraphrase, predict, rearrange, reorder, rephrase, represent, restate, summarize, transform, and translate.



One of the aims of physics education research is to find sources of student difficulties in learning physics and to formulate and assess fresh curricula and pedagogy that may diminish the difficulties (Colucci, et al, 2013; Taylor, 2014; Balawi, et al, 2016; Schuster, et al, 2018). This research was conducted based on observations of researchers, where learning only teacher-focused and the students only follow the instructions from the teacher. In addition, students rarely use other ways to solve problems, and lack discussion about difficulties in the concept of linear motion. Examination of student difficulties connected to several physics concepts is important for planning instructional strategies to decrease or eradicate problems. Previous investigations have documented difficulties in various introductory and advanced physics courses (Liang, et al, 2012; Mäntylä, 2013; Kim, et al, 2015; Yene, et al, 2018). In this study the criterion used to assess understanding of a kinematical concept was the ability to apply the concept correctly in interpreting actual motions of real objects. The research was conducted based on a learning system that focuses on the teacher and they learn physics only by following the instructions from the teacher. In addition, students rarely use other ways to solve problems, and lack discussing difficulties in the concept of linear motion. This study discusses the difficulties in the concept of linear motion included in a typical introductory physics lesson. In particular, we try to understand the relationship between time, distance, velocity, and acceleration, interpretation of the v-t graphs and verbalize a formula according to the problem provided for students.

2. Objectives

The aims of this study were to obtain an overview of K-10 students' conceptual understanding about the concept of linear motion in high school.

3. Materials & Methods

3.1 Participants

Researchers used one class consisting of 30 K-10 students (whose phase was nearly 15-16 years old) because they refer to the applicable curriculum in which the material was studied in tenth grade with the assumption that the class had studied the concept of linear motion. The students generally have broad knowledge abilities from the matter included in the handbooks.

3.2 Instruments

The instrument format in this research was multiple-choice. It was established based off of Anderson and Krathwohl's Taxonomy of explaining, comparing, interpreting, extrapolating, classifying, and exemplifying. The demands' circulation for conceptual understanding is revealed in Table 1 below.

Table 1 The demands' circulation for the conceptual understanding test

Indicators of conceptual understanding	Description of conceptual understanding's Indicator	Number of Problems	Question Number
Explaining	Able to constructs and uses a cause-and-effect model of a system or series.	3	1, 3, 5
Comparing	Able to detect similarities and differences between two or more objects, events, ideas, problems, or situations.	3	2, 4, 6
Interpreting	Able to adapt information from one form of representation to another.	3	7, 8, 9
Inferring	Able to infer grammatical principles from examples	3	10, 11, 12
Classifying	Able to determine something	1	13
Exemplifying	Able to find a specific example or instance of a general concept or principle	2	14, 15



The test instrument contained 6 aspects in multiple-choice forms with a total of 15 questions. Each question answered correctly is given a value of value 1. This score can be calculated using the Rasch model for the validity of test instruments. The instrument had a reliability value of 0.79 after testing by the previous test. That is, the items on the test instrument used can be said to be reliable. And, the instrument had a 'superior' unidimensionality (validity) measure, where the index of raw variance explained by measurement was above 60% (Sumintono & Widhiarso, 2014) as shown in **Figure 1** below.

INPUT: 30 Person 15 Item REPORTED: 30 Person 15 Item 2 CATS MINISTEP 4.3.2			

Table of STANDARDIZED RESIDUAL variance in Eigenvalue units = Person information units			
	Eigenvalue	Observed	Expected
Total raw variance in observations =	88.1998	100.0%	100.0%
Raw variance explained by measures =	58.1998	66.0%	65.5%
Raw variance explained by persons =	3.6043	4.1%	4.1%
Raw Variance explained by items =	54.5955	61.9%	61.4%
Raw unexplained variance (total) =	30.0000	34.0%	100.0%
Unexplnd variance in 1st contrast =	16.8737	19.1%	56.2%
Unexplnd variance in 2nd contrast =	4.2491	4.8%	14.2%
Unexplnd variance in 3rd contrast =	2.6247	3.0%	8.7%
Unexplnd variance in 4th contrast =	1.6024	1.8%	5.3%
Unexplnd variance in 5th contrast =	1.2015	1.4%	4.0%

Figure 1 The result of unidimensionality (validity) using the Rasch model

A model of the preface for the conceptual understanding test is revealed in Figure 2. The test grades managed by scheming the number of questions answered correctly.

No. Question	Indicator	Aspects of Concept Understanding	Question	Knowledge Dimension	Answer key
1	Explaining understanding of motion	Explaining why things are said to move	<p>Bayu rides a motorcycle like the following picture:</p> <p>The correct statement to explain Bayu's motion is....</p> <p>A. Bayu and motorbikes are moving towards traffic signs because both of them have changed their position on traffic signs.</p> <p>B. Bayu moved towards traffic signs and motorbikes because Bayu experienced a change of position towards both</p> <p>C. Bayu and motorbikes are moving towards the traffic signs because of a change in track</p> <p>D. Bayu moves on motorbikes and traffic signs because of changes in the track</p>	Factual	B

Figure 2 A sample of rubrics for concept understanding test

3.3 Research Design

The method used in this research was single case research, specifically embedded design. This design is not limited to one type of analysis, such as quantitative or qualitative ones, but allows for a diversity of methods that may be useful within a sub-unit (Siniauskaya, et al, 2016). The research school was selected based on quality of the school and its students: not too low and not too high so that the results could be used as an illustrative and give a general impression. The research was done by taking data by giving the concept understanding test on linear motion once. This test took two hours of class time, where one hour of lessons is 45 minutes. The test was given to students who had earlier studied the concepts tested in



this test. Then the results were processed statistically and then analyzed. Meanwhile, the research procedure performed is shown in Figure 3 below.

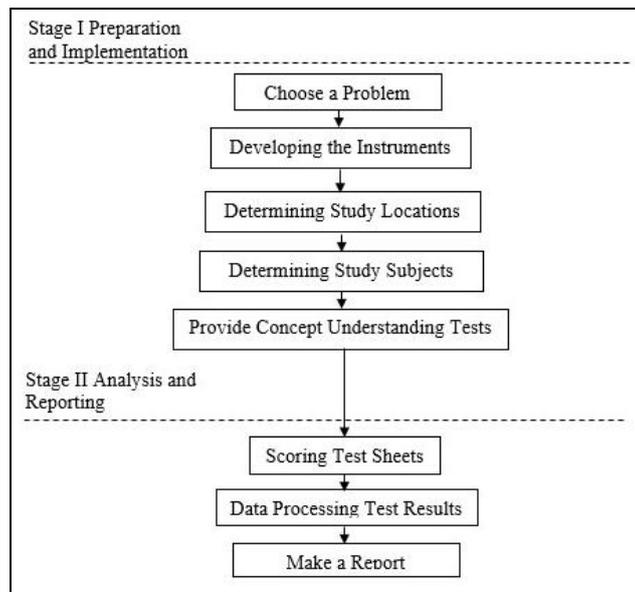


Figure 3 Research procedure

4. Results and Discussion

The result of the students' conceptual understanding test on the linear motion is revealed by the average student score in general, that is 42.89. The maximum mean score of all students answered correctly was 100, with the maximum value for each question is 1. In other words, the students' conceptual understanding gained from the test results were only 38.42%. Figure 4 shows the average score of each aspect of creative thinking ability.

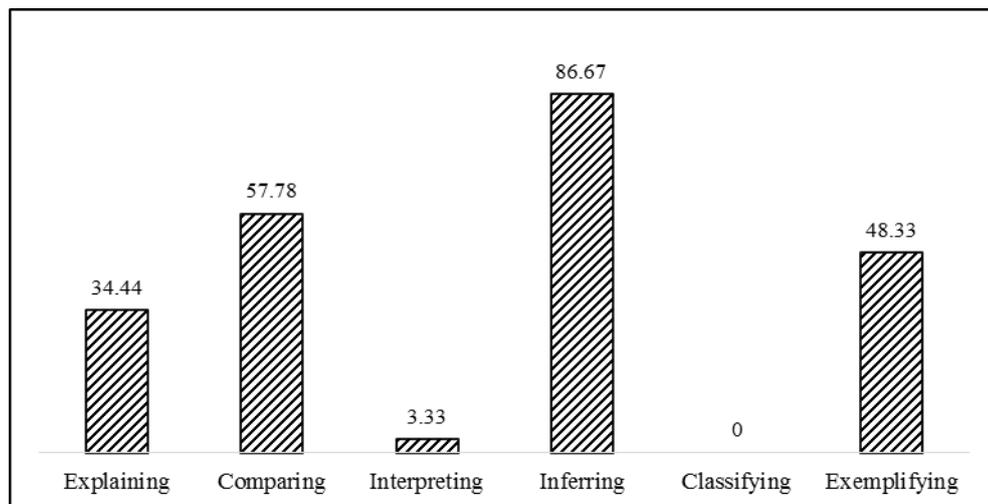


Figure 4 Average of students' conceptual understanding on each aspect



(II), and (IV)". This is in accordance with research from Endler & Bond (2000) in that students still do not understand to classify graphs and translate into sentences.

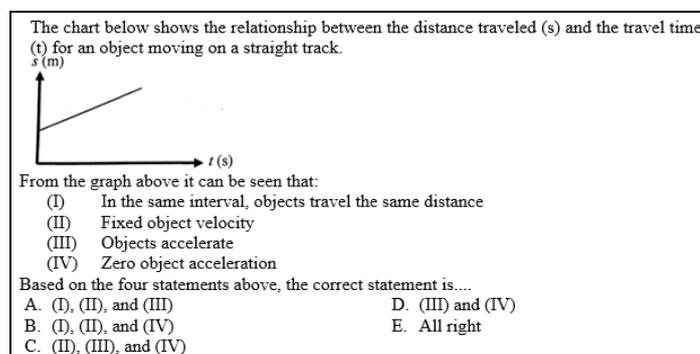


Figure 6 The example of an classifying question

The reason behind that problem is in secondary schools, most teachers do not familiarize students with understanding until the classifying stage, and usually teachers are only trained for the stage of extrapolating. In fact, classroom learning activities are based on observing and interviewing high-level students, as they learn physics only by following the instructions from the teacher. In addition, students rarely use other ways to solve problems. Ideally, teachers should provide opportunities for students to discuss, conduct laboratory experiments, work together as a group, either collaboratively or cooperatively, or occasionally carry out learning activities such as practicum outside the classroom in an open environment to help students understand the concepts (Reis, 2014). Not only that, but teachers must also build positive relationships between teachers and students, such as mutual respect, show creative attitude, encourage students to leave their comfort zone, and foster confidence in their own conceptual understanding (Artz & Armour-Thomas, 2001). Therefore, students' conceptual understanding in some aspects of the student's average score is low, especially in the classifying aspect. From students' answers, it can be seen that the answers given by students do not match the expected answers. This is in accordance with previous research which states that students find it very difficult to solve questions on interpreting and classifying aspects in learning physics (Mulhall & Gustone, 2012; Psillos, et al, 2016; Airey & Linder, 2017; Avargile, et al, 2018).

5. Conclusion

Based on the outcomes of research that had been directed, it is identified that the teacher had provided conceptual understanding in physics learning activities. But only on the aspects inferring, comparing and exemplifying, and on the aspects explaining, interpreting, and classifying is also very minimal. Students' creative thinking ability is generally low, indicated by the average score of 42.89 or 38.42% of the maximum score. Similarly, the students' conceptual understanding of each aspect is still relatively low. This is indicated by the average score of some aspect of students' conceptual understanding that is 34.44 for the explaining aspect, 3.33 for the interpreting aspect, and 0 for the classifying aspect. Based on the case study, that have been conducted, researchers want to apply the Conceptual Change Labs (CCLabs) learning model so that students get the opportunity to discuss, conduct laboratory experiments, work together as a group, either collaboratively or cooperatively to expose their beliefs and share ideas with classmates by making connections between concepts they have learned in class and other related concepts and ideas, or occasionally carry out learning activities such as practicum outside the classroom, in an environment open to help students trigger their understanding of the concept of linear motion.



6. References

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