Multi-Representation Approach in Improving 1-Dimensional Kinematics Conceptual Understanding

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ABSTRACT

This study aims to improve students' understanding of 1-dimensional kinematics concepts through a multi-representation approach. A total of 42 physics teacher candidates participated in this study, which used a one-group pretest-posttest experimental design. The instrument used was 18 multiple-choice questions that included various concept representations, such as mathematical, graphical, tabular, pictorial, and verbal. The results showed a significant increase in students' concept understanding after the application of multi-representation learning. The pretest mean score was 44.44, which increased to 89.81 on the posttest, with an n-gain of 0.81 (high category). The paired sample t-test showed a significant difference between the pretest and post-test (Sig. 2-tailed = 0.000). The multi-representation approach allows students to understand concepts from various points of view, helps reduce misconceptions, and supports various learning styles. However, this study has limitations in the design of feedback and formative assessment, which are important to improve in future research to strengthen the effectiveness of learning.

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1. INTRODUCTION

Physics learning has a vital role in shaping our understanding of the physical world that we face daily. As one of the basic branches of science, physics helps explain natural phenomena with principles that can be applied in various fields of life. One of the crucial basic topics in physics is 1-dimensional Kinematics [1]–[4], which studies the motion of objects in a straight line. Understanding kinematics is very important because it is the foundation for understanding other more complex physics concepts [5]. In physics learning, concept understanding is a very important aspect [6]–[9]. Concept understanding refers to the ability of students to understand the deep meaning of a topic, not just memorizing formulas or problem solving steps. Students who have good concept understanding are able to explain physics phenomena in their own words, as well as being able to connect theory with real applications. This is key in mastering physics, especially in fundamental topics such as 1-dimensional Kinematics.

1-dimensional Kinematics is one of the important concepts in physics that students must master from the beginning. An understanding of position, velocity, acceleration, and the relationship between these variables is necessary to analyze various motion phenomena in everyday life. Mastering 1-dimensional kinematics will help students understand more advanced physics concepts, such as dynamics, energy, and momentum. However, in reality, many students have difficulty understanding the concept of 1-dimensional

Kinematics [10]–[14]. This lack of understanding is often reflected in unsatisfactory learning outcomes and difficulties in applying the concepts that have been learned. Errors in understanding the relationship between kinematics variables, such as difficulty distinguishing between velocity and acceleration, are some examples of problems that often arise.

One of the causes of low understanding of the concept of 1-dimensional Kinematics is a learning approach that does not involve multi-representation. Multi-representation involves using different ways to explain concepts, such as graphs, diagrams, mathematical equations, and verbal descriptions [6], [15]–[18]. When learning is too focused on one form of representation, for example, relying solely on mathematical equations without linking them to visualizations, students will find it challenging to build a more holistic understanding of kinematics concepts. Therefore, this research will apply multi-representation in learning 1-dimensional Kinematics to improve students' concept understanding.

2. METHOD

This research uses a quantitative method with an experimental design, namely one-group pretest-posttest design. This design involves measuring students' concept understanding before and after the implementation of learning with a multi-representation approach to see the differences that occur after the treatment is given. The research was conducted on 42 physics teacher candidate students who had completed the Basic Physics I course. The subjects consisted of 33 female students and 9 male students. This research was conducted in the Department of Physics at one of the universities in East Java, Indonesia.

The instruments used in this study were 18 multiple-choice questions designed to test students' understanding of the concepts of position, displacement and distance traveled, speed and velocity, and acceleration. The questions were presented in various representations, including mathematical, graphical, tabular, pictorial, and verbal representations, to measure students' multi-representation skills.

Data analysis was conducted using descriptive statistics, paired sample t-test to see the difference between pretest and posttest, and calculation of n-gain value to measure the improvement of understanding. The n-gain category is based on the provisions of low if ⟨g⟩ G 0.25, lower–medium if 0.25 ≤ ⟨g⟩ G 0.45, upper–medium if 0.45 ≤ ⟨g⟩ G 0.65, and high if ⟨g⟩ ≥ 0.65 by Sutopo & Waldrip [19].

3. RESULTS AND DISCUSSION

The results of this study are based on the concept understanding scores obtained on the test. Descriptive analysis data of students' conceptual understanding scores as shown in Table 1.

Table 1. Descriptive analysis data of students' concept understanding scores

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
Pretest	42	16.67	77.78	44.44	11.31	.601	.365
Post-test	42	77.78	100.00	89.81	7.04	.276	.365
Valid N (listwise)	42						

Based on the descriptive analysis in Table 1, it can be seen that there is a significant increase in students' concept understanding on the topic of 1-dimensional Kinematics after the implementation of learning with a multi-representation approach. In the pretest score, the number of students (N) involved was 42 people, with a minimum score of 16.67 and a maximum score of 77.78. The mean of the pretest score was 44.44, with a standard deviation of 11.31, indicating considerable variation in concept understanding before learning. The skewness for the pretest data was 0.601 with a standard error of 0.365, indicating a slightly skewed distribution of scores to the right or more students scoring low. After implementing the multi-representation approach, the post-test scores showed a significant increase. The minimum score on the posttest was 77.78, while the maximum score reached 100. The average posttest score increased to 89.81 with a smaller standard deviation of 7.04, indicating that students' concept understanding was more evenly distributed after the learning. The skewness of the post-test data was 0.276, with a standard error of 0.365, indicating that the distribution of scores was closer to normal. Supported by the results of the normality test that we have done, it is obtained that the sig. > 0.05. These results indicate that the pretest and post-test data are normally distributed. The results of the normality test are shown in Table 2.

Table 2. Normality Test Result

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pretest	.191	42	.001	.924	42	.008
Post-test	.202	42	.000	.865	42	.000

a. Lilliefors Significance Correction

Furthermore, since the data was normally distributed, to see the significance of the difference in concept understanding scores between the pretest and post-test, we used the paired sample t test. The test results are shown in Table 3.

Table 3. Paired Samples T Test Result

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pair 1 Pretest - Posttest	-45.37	8.22	1.27	-47.93	-42.81	35.75	41	.000

Based on the results of the paired sample t-test in the Table, the mean difference between the pretest and post-test scores is -45.37, with a standard deviation of 8.22 and a standard error of the mean of 1.27. The 95% confidence interval of this mean difference is between -47.93 and -42.81, which indicates that the difference between the pretest and posttest scores is within that range with a 95% confidence level. The result of the t-value is 35.75 with 41 degrees of freedom (df). The significance value (Sig. 2-tailed) is 0.000, which is smaller than 0.05. This shows a significant difference between the pretest and posttest scores of understanding the concept of 1-dimensional Kinematics. Thus, it can be concluded that implementing learning with a multi-representation approach significantly improves students' concept understanding on the topic of 1-dimensional Kinematics. And then, based on the calculation results, the n-gain is 0.81. These results indicate that the increased students' understanding of the concept of 1-dimensional kinematics has increased in the high category.

Learning with a multi-representation approach is proven to improve understanding of 1-dimensional Kinematics concepts because this approach involves multiple ways of presenting information and concepts [20]. In physics, particularly in 1-dimensional kinematics, concepts such as position, displacement, velocity, speed, and acceleration often require a deep understanding and the ability to connect different forms of representation, such as graphs, mathematical equations, drawings, and verbal descriptions. A multi-representation approach allows students to see a concept from multiple perspectives [21] – [23], helping them build a more comprehensive understanding. For example, mathematical representations provide a clear numerical foundation, while graphs help students visualize how variables change over time. Tables and pictures provide a more concrete and intuitive picture, while verbal descriptions help students relate concepts to real situations.

By viewing the same concept through multiple formats, students more easily understand the relationship between concepts, such as the difference between speed and velocity or how changes in position relate to acceleration. This reduces the possibility of misconceptions that often arise when students are only given one type of representation, for example, mathematical equations alone without supporting visualizations. In this study, the significant increase in posttest scores indicates that the multi-representation approach allows students to assimilate and integrate information more effectively [24], which ultimately improves their concept understanding. In addition, multi-representation also supports various learning styles. Some students may understand concepts more easily through graphical visualization, while others are more likely to understand through the manipulation of mathematical symbols. This approach provides flexibility in learning and makes the material more accessible to different types of learners, ultimately contributing to improved overall understanding.

Although this study significantly improved students' concept understanding, it also has limitations. One of the limitations of this study is that feedback and formative assessment have not been optimally designed during the learning process. In fact, these two elements are very important in improving students' concept understanding more effectively. Good feedback provides students with information about their mistakes and helps them improve their understanding. Meanwhile, formative assessment allows teachers to continuously monitor students' progress and adjust learning strategies according to students' needs. For future research, it is important to design a more systematic feedback and formative assessment mechanism. By involving formative assessment in a structured way, students will be more involved in the process of reflection on their own learning, which has the potential to improve understanding and retention of concepts sustainably.

4. CONCLUSION

The results of this study indicate that learning with a multi-representation approach significantly improves students' concept understanding on the topic of 1-dimensional Kinematics. Based on descriptive analysis, there was a significant increase in concept understanding scores after learning, with a pretest average score of 44.44, which increased to 89.81 in the post-test. Paired sample t-test showed a significant difference between the pretest and post-test scores (Sig. 2-tailed = 0.000), with an n-gain increase of 0.81, which is included in the high category.

The multi-representation approach allows students to understand concepts from various points of view through different representations, such as graphs, mathematical equations, drawings, and verbal descriptions. This helps reduce misconceptions and supports various learning styles, thus strengthening the understanding of 1-dimensional Kinematics concepts. Although this study showed positive results, limitations related to the less than optimal design of feedback and formative assessment during learning need to be considered for future research, to further improve learning effectiveness and sustainable concept understanding.

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