Multi representation approach to increase the students’ conceptual understanding of work and energy

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Abstract. This paper aims to reveal the effectiveness of a multi-representation approach in work and energy learning in improving students’ conceptual understanding. This research is an experimental study with the design of one group pretest-posttest design. The research subjects were 42 undergraduate students of Physics Education in the subject matter "physics material and learning I". The test instrument consists of 15 reasoned multiple choices questions. Based on the results of data analysis using paired sample t-test obtained t = -9.39 (p = 0.00) so it can be concluded that the multi-representation approach in work and energy can significantly improve student understanding of concepts with N-gain of 0.41 and d-effect size of 1.76. Before learning with a multi-representation approach, many students had difficulties to interpret the diagram of kinetic-potential energy. But it have minimalized after instruction. Learning with a multi-representation approach is effective to increase the students conceptual understanding of work and energy because it helps students understand the concept of physics as a whole.

1. Introduction
One of the important abilities in learning science is representing various phenomena and problems [1]. Representation is something that explains, represents or symbolizes an object or process so that it is easier to understand objects or processes more clearly. This is important in learning mathematics [2] and physics [3]. Representations are related to communication skills and problem solving [4]. In learning, students not only use representation but also use multi representations [5]. If students’ understand concepts and problems, it will be indicated by the ability to build multiple representations. Students are also required to be able to change from a representation to another representations [6,7].

In physics context, many phenomena and problems that can be explained and solved by various representations. Therefore, multi representation is an important aspect that needs to be built by students. Multi representation is useful for representing a similar concept with different formats, such as verbally, images, graphics, and mathematics [8]. In physics context, multi-representation is a form of mastery and broad communication of physics concepts. In the context of learning science, especially physics, we can use the multi representation as a learning physics approach. The students who are understand the concepts in various representations, they certainly have a deeper concept [9]. This is related to each
student having the ability to improve skills that are more prominent than other abilities. There are students who are more prominent in their verbal abilities than their spatial and quantitative abilities, but there are also the opposite. One topic in physics learning that needs to build knowledge with multi representation is work and energy. The effectiveness of using a multi-representation approach in work and energy learning will be discussed in this article.

2. Methods
This study uses the Embedded Experimental Model research design [10] with a mixed method research approach. The research subjects 42 undergraduate students of Physics Education at the State University of Malang in the subject matter "physics material and learning I".

This study aims to see the effectiveness of interactive conceptual learning with a multi-representation approach to the topic of work and energy. To achieve this goal, a test instrument is used to measure concept understanding. The test instrument consists of 15 reasoned multiple choices questions. Improved understanding of student concepts is seen from the difference in pretest-posttest scores using paired t-test. Program effectiveness is measured by the N-gain score [11] from pretest to posttest.

3. Results and Discussion
3.1. The increase of students’ conceptual understanding score
In this article, an increase in the score of students’ understanding of work and energy concepts is discussed. Table 1 shows descriptive data understanding the concepts of work and energy.

|                | Pretest | Posttest |
|----------------|---------|----------|
| Min.           | 20.00   | 40.00    |
| Max.           | 80.00   | 93.33    |
| Mean           | 47.96   | 69.26    |
| Std. Dev       | 13.51   | 10.72    |
| Skewness       | 0.14    | -0.46    |

Based on Table 1, it can be said that the score for the students’ pretest-posttest conceptual understanding has increased. The average of conceptual understanding score increased from 47.96 to 69.26. In addition, the minimum and maximum scores of student scores also increased. But this needs to be tested statistically. To test the differences between the pretest-posttest scores, a paired sample t test was used. Before using the statistical test, it is first confirmed that the data is normally distributed. Based on the descriptive statistics table, the Skewness value for pretest-posttest data lies between -1 and +1 so that it can be said that the data is normally distributed, therefore the t test can be use. The results of the paired sample t test are shown in Table 2.

|                | Pre - Post | t     | df | Sig. (2-tailed) |
|----------------|------------|-------|----|-----------------|
| Mean           | -21.29     | 9.39  |    | 0.00            |
| Std. Dev.      | 13.59      |       |    |                 |

The results of the paired sample t test as shown in Table 2 show that t = -9.39 and sig. (2-tailed) = 0.00 so it can be concluded that there is a significant difference between the pretest score and the posttest score. Ngain and d-effect size are used to see the increase due to the influence of the implementation of
a multi-representation approach. Based on the results of the analysis obtained \( \text{Ngain} = 0.41 \) and \( d\)-effect size = 1.76. This value shows that there is a strong influence on the implementation of a multi-representation approach in improving understanding of the concept of work and energy. Based on several studies also found that learning with multiple representations can improve students' ability to solve problems [12]. Not only helps to understanding concepts, a multi-representation approach can also help students become a good problem solvers [2,13].

In the learning process, students are trained to build their own knowledge. Students are trained to build various representations for each concept. Some representations that are trained in students are verbal, mathematical, graphs, diagrams, tables, and images. It aims to build students' knowledge so that it is more complex, intact, and entrenched. So that when they need that knowledge to explain various phenomena and solve problems, students will quickly invoke the knowledge they already have.

3.2. Sample of question: the highest improvement of conceptual understanding score
For the various questions given to students, there is 1 question that experienced the highest increase. The problem is shown in Figure 1. The given case is a beam thrown from the height \( h \) from above the ground and the speed \( v \) upward. In this question students must determine the \( K \) and \( V \) diagrams. The diagram in the question shows that the origin of the throw is a reference point so that if the object is below the reference point, its potential energy is negative.

When solve the question, only 10 (23.81%) students’ chose the option (B) at the pretest. That means there are 76.19% of students’ who choose the wrong option. At the posttest, the number of students’ who chose option (B) increased to 34 (80.95%) students’. At the time of the pretest many students’ did not understand how to interpret the diagram, so they had difficulty in solving the problem. During learning, students’ are trained to build diagram representations in various contexts of problems and concepts of physics. So that in solving these problems at posttest, students’ do not have difficulties. Effectiveness of multirepresentations to improve the students’ conceptual understanding is in accordance with several studies (such as, [14–17]). The ability of students’ to build and understand various representations has important aspect to construct the knowledge. Therefore, in the learning process the teacher must not only prioritize one representation.
4. Conclusion
The implementation of multi-representation approach is effective to increase the students conceptual understanding of work and energy because it helps students understand the concept of physics as a whole. Based on the results of data analysis using paired sample t-test obtained $t = -9.39$ ($p = 0.00$) so it can be concluded that the multi-representation approach in work and energy can significantly improve student understanding of concepts with $\text{N-gain of } 0.41$ and $d$-effect size of $1.76$. To understand the concept of physics well, students must be able to build knowledge in a variety of representations. The more representations that are built will show better understanding.

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