Predict, Plan, Observe, Explain and Write (PPOEW): A Strategy to Prevent Students’ Misconceptions On Work and Energy Topics

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Abstract. This research based on students’ misconceptions on work and energy topics. Students’ misconceptions could be prevented through Predict, Plan, Observe, Explain and Write (PPOEW) strategy on their learning. This research methodology was conducted in a quasi-experimental design with control group of pre-test and post-test for 18 students consist of 13 girls and 5 boys as research subjects and 37 students as control subject. The four-tier test used as an instrument to identified student’s misconception on Work and Energy topics that has been developed in previous research. The data analysis focused on how effective was the PPOEW with computer simulation to reduce students’ misconception in the concept of positive energy, negative energy, conservative and non-conservative energy, work-kinetic energy theorem, and energy conservation law. According to the result of the research, PPOEW reduces students’ misconception from 52% to 14%. In addition, PPOEW also increased student’s concept shown by an N-gain value that about 0.5 (medium).

1. Introduction
Misconception is a problem that is often encountered by learners. The term of misconception refers to the difference between student’s understanding and right concept of science theory [1]. While misconceptions still exist even though students have acquired a lot of physics learning, it indicates that learning processes cannot overcome misconceptions if the focus of learning is not targeted at misconceptions. A difficulty to overcome misconceptions is that teachers themselves do not try to overcome misconceptions [2]. The only thing to overcome misconception is teachers should identify their own students existing ideas by diagnostic assessment [3]. A way that can be used to identify misconception is a multiple-choice test with reason. One of the test that can be used to identify misconceptions is the four-tier test. In the four-tier test, there are four levels such as question, level of answer, reason, and levels of reason [4].

As a big problem in learning process, misconceptions should be prevented by the teachers with suitable strategy in teaching process. The most students feel hard to understand physics concept, especially abstract concept that has studied with conventional teaching method. Related to misconceptions experienced by students and abstract concepts that are difficult to understand, computer simulation can be used to explain or show a difficult phenomenon that cannot even be done in a real class. Computer simulations are programs that contain a model of a system (natural or artificial, e.g.,
equipment), or a process [5]. The use of learning media that can provide multimedia aspects is an alternative media to improve students' understanding and attract students' interest [6]. Strategy or methods and technologies is necessary in physics education to be used properly due to impossibility or lack of information [7]. The research which used PPOEW and computer simulation have a good combination of strategy and technology to improve student’s concept. Based on the simulation of physics matter, it is possible to investigate among other abstract phenomena [8]. Sciences learning should be able to facilitate students in identifying objects and phenomenon, describing phenomenon, purposing question related to the phenomenon, constructing explanation, testing explanation by other different ways and communicating their arguments [9]. PPOEW (Predict, Planning, Observe, Explain, Write) is a strategy that can make students more easily understand the material and play an active role during the learning process [10]. This strategy requires learners to first predict and record the outcome of an event giving reason to support their prediction [11]. Beside that, based on the research of Kibirige, it show that learners in the experimental group (EG) taught using POE performed better in the post-test than their counterparts in the control group (CG) taught using traditional method [12]. It should be best way to use PPOEW as a strategy to prevent students’ misconception because students have to find their own physical concept during learning that can be done through PPOEW, so that the concept obtained is the result of student's own construction. One of the main goals of education is that students should learn how to use the data which they gather for the interpretation of events and experiences [13]. Through this strategy, students can exchange their ideas or discussions to create active learning in the classroom. Discussion among friends can help students to develop and re-examine the concept and knowledge they have gained from the result of observing and comparing with the concept of their friends [14]. Understanding a concept requires individuals to organize knowledge as a propositional network, linking together various related sub-concepts and constructing cross-links between these sub-concepts [15]. They may need to develop a new theory of the underlying factors behind the experiment [16]. This strategy involves students in predicting the results of an experiment demonstration, planning to prove their prediction, observing the demonstration, explaining any discrepancies between their prediction and their observation, and finally write down the concept that had constructed. Whether used individually or in collaboration with other students, PPOEW tasks can help students explore and justify their own individual ideas, especially in the prediction and reasoning stage. If the observation phase of the POE task provides some conflicts with the students' earlier predictions, reconstruction and revision of the initial ideas are possible [15].

2. Purpose of the study
This study aims to analyze students’ misconceptions on Work and Energy topics, the following research questions are formulated.

   How is the difference in percentage of misconceptions between pre-test and post-test?
   How is the effectiveness of the PPOEW strategy to reduce students’ misconceptions on Work and Energy topics?

3. Method
This research methodology was conducted in a quasi-experimental design with control group of pre-test and post-test for 18 students research subjects and 37 students as control subject. The four-tier test used as an instrument to identified students’ misconception on Work and Energy topics that has been developed in previous research.

The data analysis focused on how effective was the PPOEW with computer simulation to reduce students’ misconception using N-gain value [17] and more significant influence of the experimental class with the control class in preventing misconceptions was analyzed using t-test. The misconception for each category also explained in the form of percentage.
4. Findings and Discussion
Misconception is the difference of students’ concept with the right concept. Student’s misconceptions on Work and Energy topics had been identified by using the four-tier test of Work and Energy. The students' answer are categorized into four conceptions of Scientific Knowledge (SC), Partial Understanding (PU), Misconception (M), and Lake of Knowledge (LK) [18].

4.1. Percentage of students’ conceptions
The percentage of students’ conceptions between pretest and posttest can be seen in Graph 1.

It significantly decreased from pre-test to post-test of 38% in the context of misconception. Students’ misconception of 52% in pre-test transformed into another conception such as SC, PU, and LK. Moreover, the distribution of misconceptions in the pre-test into another category in the post-test can be seen in Graph 2.

The transformation of misconception into another conceptions can be analyzed for each item that has been answered by students on pre-test and post-test. For example, for item number one that relates to positive work and negative work, as many as 8 out of 15 students are misconception. The transformation of the conception (misconception category) by eight students changed to SC, PU and there was one student who was LK. The transformation of it can be seen in Figure 1 with red (or the bigest circle) representing Misconception in pretest, green (or small circle on the top) representing SC, yellow representing PU, and grey representing LK.
4.2. Misconception Analyse
The analysis focused on the misconception category before and after the treatment, Graph 3 show percentage between pre-test and post-test.

Based on Graph 3, the most misconception on work and energy topics was the sub-concepts of conservation energy law up to 70%, then work-energy theorem is 56%, conservative and non-conservative force is 48%, negative and positive work is 44% and sub-concept of energy change is 35%. Based on the data in Graph 3 it can also be seen on the percentage of post-test that misconceptions on all the sub-concept have decreased. The decrease of misconceptions in the sub-concept of conservation energy law is 48%, in the sub-concept of work-energy theorem is 40%, the conservative and non-conservative force is 33%, the positive and negative work is 44%, and in the sub-concept of energy change is 25%. The decrease of misconception is caused by the PPOEW strategy with computer simulation.

Students were given explanations by the teacher regarding a phenomenon related to the law of conservation energy. Through the provided worksheet, students were asked to predict how the mechanical energy of the wrecking ball that moves from the equilibrium position to the highest position when there was no frictional force at each position. For example, one of the students with the initials DN predicts that “the energy of the ball will decrease as the ball moves from the equilibrium position to the highest position, the reason given by the student is that in that condition the friction force is ignored and the wrecking ball moves slower then the mechanical energy down. The student chose an option that he believes in the prediction that had been made.
Through this prediction stage, it could be analyzed that when student gave wrong prediction and felt confident with the prediction, so the student was in misconception category. From all of the students who made predictions, some gave wrong predictions and were unsure of the predictions, others gave true and feel confident with those predictions. The findings of misconception on this concept is students assumed that even the frictional force is neglected, and the law of energy conservation applies, the student still assumed that when the kinetic energy change, so does the mechanical energy. In addition, when energy conservation laws applies, students assumed that mass affects the velocity of objects. Through PPOEW strategy with computer simulation, students come to know when only a conservative force on the system, then the mechanical energy of the object remains constant. Figure 2 was used to determine the effect of mass on the velocity when the law of energy conservation applies.

Through the simulation, students could vary the variable by combining the mass and the initial height, then see how the velocity of the object at each position. Through observation and calculation performed by computer simulations, students become aware that the mass does not affect the velocity of the object. So the concept undertaken by students in order to reduce misconception begin with predict and writing as the last stage. Based on the results, PPOEW sheet with computer simulation increase the understanding of concept on work and energy topic which is in line with the research of Jong that providing assignments with the simulation improved students’ performance on intuitive knowledge [5].

N-gain value is used to inform how effective PPOEW strategy to prevent misconceptions. N-gain value obtained by the students is -0.5 at the medium category. The minus sign indicates that there was a decrease in misconceptions on pretest and posttest. From the analysis of N-gain values, 100% of students experienced a decrease in misconceptions. The decrease of misconception was divided into three categories high, medium and low. The percentage of misconceptions in each category can be seen in table 1.

| Class        | Percentage of category (%) |
|--------------|---------------------------|
|              | high | medium | low  |
| Control      | 0    | 16     | 78   |
| Experimental | 6    | 67     | 27   |

Based on the data in Table 1, accompanied by the classification of the decrease of misconceptions that were in the low category had a smaller percentage, it can be concluded that the PPOEW strategy
with computer simulation is effective to prevent student misconceptions on Work and Energy topics. That results in line with the results of research by Samsudin that computer simulation has increased students’ conception on the topic of momentum and impulse [19]. In addition, based on t-test ($t_{\text{calc}} = 5.89$ dan $t_{\text{table}} = 1.67$) it can be seen that the use of PPOEW significantly prevent misconceptions on work and energy topic compared with conventional strategy.

5. Conclusion
The use of PPOEW strategy with computer simulation effected on the reduction of misconceptions on work and energy topics. Based on the t-test, the use of PPOEW strategy with computer simulation gives more significant effect compared to the use of conventional model to reduce misconception. PPOEW strategy effectively reduced the misconceptions of students on work and energy topics with the N-gain value in the experimental class entering the high category of 6%, medium category 67%, and low category 27%. The percentage of misconception rate in the experimental class decreased greatly in pre-test and post-test from 52% to 14%.

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