Training Students’ Science Process Skills through Didactic Design on Work and Energy

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Abstract. Science Process Skills (SPS) has not been optimally trained to the students in the learning activity. The aim of this research is finding the ways to train SPS on the subject of Work and Energy. One shot case study design is utilized in this research that conducted on 32 students in one of the High Schools in Bandung. The students’ SPS responses were analyzed by the development SPS based assessment portfolios. The results of this research showed the didactic design that had been designed to training the identifying variables skills, formulating hypotheses, and the experiment activity shows the development. But the didactic design to improve the students’ predicting skills shows that the development is still not optimal. Therefore, in the future studies need to be developed the didactic design on the subject Work and Energy that exercising these skills.

1. Introduction
Science is a combination of processes and products that are related each other [1]. The process is a series of activities that needed to achieve the product [1]. This requires learning activities able to make the students’ activeness in order to build up the students’ knowledge through a series of activities that encourage students toward discovery process [2]. In order to find a knowledge is needed some skills such as observing, measuring, experimenting, interpret the data, communicate, and so on [2]. These skills can be used in the process of finding a knowledge which is then referred to as the Science Process Skills (SPS). The importance of SPS in science led to the various countries worldwide emphasis on SPS and developing higher skills through learning approach that centered on the student [3]. Therefore, the necessary means (didactic design) to exercising students’ SPS.

However, this research shows that students’ SPS are still not optimally trained in the classroom because of the experience lack in the learning activities investigation [4]. The similar results were found from preliminary studies through observation in the schools shows that the learning science is still dominated by the transfer of knowledge. The experimental activity does not start from the observation experiment, the students are not involved in building and designing experimental investigation questions. This is not counterpart with the government’s recommendation to use the scientific approach in the learning activities [5]. According to the research findings, it could be suggested to a teacher requires in analyzing the students’ characteristics. The students’ learning capability will determine the role of a teacher conducting the learning in a class [6]. A learning process is one of the important aspects for the improvement of students’ conceptual achievement [7]. Based on the observations result, it found that students’ difficulty in the identifying variables based on the observations, constructing predictions, constructing hypotheses, and experiment. Several studies have
tried to train students’ SPS. However, not all of the students’ skills be able to train optimally. Some results of these studies which are expressed by Lati that students’ interpret data skill and construct the conclusion are still in fairly level [4]. Hodosyova, et al. reveals that the students’ SPS is still low in terms of designing experiments and hypothesize [8]. It is also found by Akpokorie and Omajuwa expressed by Jack that of 15 SPS recommended curriculum, 70% of students having difficulty in mastering these skills [9].

The didactic design is the learning plans that include the ways to teach certain concepts through the students’ responses on a draft action learning provided [10]. The aims of this research are trying to find the didactic design for training high school students’ SPS on the Work and Energy through the SPS approach. Related to the subject of Work and Energy, the SPS will be trained to students can be seen in the SPS chart that designed by Rezba as shown in Figure 1 [11].

Based on Figure 1, the steps of SPS approach that utilized to design ways to train students’ SPS that covering the aspects of observation to identify the variables and predicting, identifying variables to constructing the hypothesis, and then the students are invited to designing investigations to do the experimenting. Every aspect had been drilled through the questions that contained in the students’ worksheets that were developed based on the SPS aspects. According to this description, the research will be able to describe the didactic design for training the SPS on the subject Work and Energy based on the analysis of portfolio assessment on students’ worksheets.

2. Experimental Method
This study was conducted with the experimental study design using the one-shot case study to find the ways to train students’ SPS on the subject of Work and Energy (didactic design). The study was conducted in one of the high schools in Bandung with a sample of 32 eleventh grade students were obtained by purposive sampling based on the observation of the students’ SPS. The students’ SPS responses were analyzed based on the increase of SPS from the assessment portfolio to the student’s worksheets that developed from the SPS aspects. The students’ worksheet is given to the students during three meetings. The scores in every SPS aspect obtained by the students during the three meetings compared to finding the students’ SPS development. The percentage of student’s score in the range of 0-50, 51-60, 61-70, 71-80, and 81-100 are interpreted as very poor, poor, fair, good, and excellent [4].

3. Result and Discussion
Based on the results of the research data acquisition, it obtained the description of the development students’ SPS average score to identifying variables during the three meetings is shown in Figure 2.
Figure 2. Graphics development of identifying variables during the three meetings.

Figure 2 shows that the didactic design that had been designed could be training students’ identifying variables skills during the three meetings. At the time of learning activities, the teacher begins the learning process by featuring the demonstrations directly in front of the class. Then the teacher asks the students to observe the demonstration that shown and ask the students to determine the quantities or the variables that observed based on the demonstration activity.

At the first meeting, the teacher did not use other media to aid the students doing the observation on the abstract things. For example, the velocity of the toy car, the teacher did not use a stopwatch to help students determine the fastest moving car. Teachers already planning a demonstration before assuming that students be able to identify the variables contained in the demonstration. However, students’ difficulties in determining the variables that are abstract. Based on the findings of the problems at the first meeting, the teacher utilized the other media to aid in the students doing the observation for the next meeting.

In the second meeting, in order to know how much the energy of an object utilized the media such as the barrier boards. The further displacement of the barrier board from its first position after crushed by the toy car caused the energy on the toy car are also getting bigger. In observation requires a creative teacher activity by letting something abstract into something that can be observed directly [12].

At the third meeting, teachers utilized the video to help the students on doing the observation. This had been conducted so the students could observe the phenomenon more clearly. Johnston revealed that the utilized of the observation tools such as the projectors could assist students in the observation activity [12]. Rezba stated that the activities of the observations can be qualitatively and quantitatively [11]. The quantitative observations can be done with the help of measuring instruments. The goal is that the nature of the object can be observed by the students more closely.

On the Figure 3 displayed the tendency of students’ answers on aspects of identifying the variables at the third meeting which is in conformity with the indicators that said by Rezba.

Figure 3. Photo the Example of the Tendency Students’ Answer in Identifying Variables in the Third Meeting

The second aspect that measured is the predicting aspect. The development of the Predicting aspects during three meetings is shown in Figure 4.
Figure 4. Graphics development of predicting during the three meetings

Figure 4 shows that students’ predicting skill had been an increase in the first meeting to the second meeting, but the enhancement is not too great. At the third meeting, the students’ predicting skills progressing into the Excellent category. According to Rezba, the predictions start from the observation activities, inferring to give an explanation for the observation, and predicting what will happen [11]. The predicting stage on the learning activities in the first and second meetings, the teacher asks the students orally to predict what would happen without the asked students’ the reason why the predictions based on the observations. This is caused by the time limited to carry out all the stages in the learning process. Based on the phase expressed by the predicting activity requires inferring or provisional conclusions based on the observations from the teacher demonstrations [11]. This tentative conclusion that students use as a basis for making a prediction. However, at the first meeting and the second meeting, the teacher does not have students inferring or explaining the observations that have been made as an interim conclusion for students. The teacher immediately asked students to make a prediction because of the time constraints. This causes the students’ predicting skill in the first and second meeting did not experience a large increase. But at the third meeting, the teacher asked some students to give an explanation for the prediction that had been delivered. The explanation that given with regard to the demonstration displayed the teacher. It could be training students’ predicting skills so that at the third meeting they could achieve the good category.

Figure 5. Graphics development of constructing hypotheses during the three meetings

The Figure 5 shows that the skills to formulate hypotheses had been developed during the three meetings. The questions were developed to train students’ constructing hypothesis skill is that students can answer the question of what will happen to the dependent variable with independent variables were deliberately altered.

Based on the comparing of the first and second meetings, the tendency of students' answers on the third meeting already shows that students can answer the questions with a good investigation. It can be seen from the students’ answers to the question on the constructing hypotheses aspect on the students’ worksheets that provided. At the third meeting, the students are able to construct the hypotheses as expected is to relate with what happened with the dependent variable due to the variables that
deliberately tampered with. On Figure 6, shows the tendency of students' answers in answering questions on the constructing hypotheses aspect on the students’ worksheets.

![Image](https://via.placeholder.com/150)

**Figure 6.** Photo the Example of the Tendency Students’ Answer in Constructing Hypotheses in the Third Meeting

The constructing hypotheses activity starting from the identification of the variables that needed to make the phrase of the hypothesis on how the influence of the dependent variable due to the independent variable deliberately altered and fitted with an explanation for this hypothesis [11]. The identification of variables can be done by asking questions probe that display the issues that must be answered by the students [11]. This indicates that there are links between the students identifying variables skill with the constructing hypothesis skill. The improvement of students’ constructing hypothesis skills also supported by the statement of Tomkins, that observation is the basis of constructing the hypotheses. The students can identify the variables through the observation of the demonstration that displayed as a basis the hypothesis [13].

![Graph](https://via.placeholder.com/150)

**Figure 7.** Graphics development of experimenting during the three meetings

Based on Figure 7, the students’ experimenting skill due the progressing with the implementation of SPS approach in the learning process. The questions that developed is related to how students collect data, process and analyze the results of the experiment, and construct the conclusion of the trial. The tendency of students' answers on the third meeting, it has been able to collect the right data, process and analyze the data correctly, and make the right conclusions.

Rezba said that students’ experimenting skill starting from the student's ability to identify the variables, constructing hypotheses, designing experiments, collecting data, explain and analyze the findings and make conclusions on experiments that have been conducted [11]. This suggests that the skills of identifying variables, predict, and hypothesized influencing students’ experimenting skill. Correspondingly, the German revealed that the stage of experimentation done after designing the tables observation and in accordance with the procedures that have been designed [14]. The data obtained is then inserted into the table of observations. After the trial is completed, students are asked to analyze the results of experiments, construct the conclusions, provide an explanation for the conclusion and mention the mistakes that made in the study that could affect the study results. But at the first meeting and the second, the student does not provide an explanation for the conclusion and mention the mistakes made in the research. While at the third meeting, the students do so. This causes the students’ experimenting skill at the third meeting greater than the two previous meetings. Another factor is the students begin to consult the results of their experiments to the teacher at all three meetings so the teacher can explain in accordance with the difficulties experienced by the students. This action is able to construct the development of students’ skills. This is supported by Roth who
stating that students should consult with friends and teachers at each meeting on the results of the experiment were found [15].

4. Conclusion

The results of this research showed that the didactic design on the subject of Work and Energy that are designed capable of developing students’ SPS from the poor category into the excellent category. However, the study has not found ways to develop students’ predicting skill to the excellent category. This is because the learning stage in training the predicting skills still not performing as it should.

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