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The Effect of Problem Based Learning Based on Multiple Representations to the Students' Science Conceptual Understanding

The Effect of Problem Based Learning Based on Multiple Representations to the Students' Science Conceptual Understanding

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Abstract. This study aimed to determine the effect of implementing problem based learning (PBL) model based on multiple representations to the science conceptual understanding of junior high school students in temperature and heat. This study was conducted by using experimental research method with pre-test-post-test design at one of the state junior high schools in Medan. The sampling technique was using cluster random sampling. The participants of this study consisted of two classes. The first was an experimental class which was treated by implementing PBL based onmultiplerepresentations and the second was control class which was treated by implementing traditional learning, 38 seventh grade students of each. The research instrument was multiple choices, 40 items with 4 optionswhich measured students' conceptual understanding in temperature and heat. Pretest and posttest data were respectively31.71 and60.72 for control class, whereas for experimental class were 30.26and 74.01 respectively. Data were analyzed by using t-test. Based on the results of hypothesis testing, it was found that the application of PBL based on multiplerepresentations had an effect on students' understanding of the science concept in temperature and heat. The percentage of increasing N-gain conceptual understanding was respectively 42 and 63 for control and experimental class. Both were in the moderate category.

Keywords: problem based learning (PBL), multiple representations, science conceptual understanding

1. Introduction

Science is an interesting and fun lesson to learn because we can know everything that is in us and the environment around us by learning science itself. Science is the study of living things and surroundings. We can apply knowledge about nature in everyday life, for example identifying various kinds of natural medicinal plants that can cure various types of diseases without buying the drugs. Science can also learn how the living things reproduce. By learning science, we can find out various things about plants, animals, inanimate objects and how they work, till the solar system where the earth is located. Thus, we can be more grateful and admire God's creations around us. That's why learning science is important.

The importance of learning science is not in line with what is experienced by the students in the classroom environment. For some students, science is a difficult subject and one of the most dreaded subjects, especially on the middle school level. In this level, science contains the learning material about natural knowledge that is relevant to students' lives. The students are expected to identify and know the natural knowledge in their daily lives.

Based on the result of observations carried out by researchers in several state junior high schools in Medan, it was found that the teachers were still traditionally teaching science by emphasizing lecture and assignment methods. The teachers often teach science by using one representation, such as words. Teaching science requires the use of a variety of multiple representations because the students have different abilities, some are easy to learn by using pictures, some are easy to learn by using mathematical equations and so on. Sunyono and Meristin (2018)explained that the students were difficult to learn science because learning science required various representations and transformation of one representation to another representation.

Representation is something that symbolizes or represents an object. Rosengrant et al. (2007) describes that a representation is something symbolized or symbol is in an object or process. Multiple representation is a model that re-represents the same concept in several different forms (Angell et al., 2007). Examples in science include words, mathematical equations, graphs, diagrams, pictures, computer simulations, etc. (Airey and Linder, 2009). Using different modes of representation can make concepts easier to understand and more enjoyable for students.

Multiple representation is very suitable for teaching science that has abstract concepts. Learning science with multiple representations can provide a better conceptual understanding to the students. Presenting several representations related to a process or concept, such as words, mathematical equation, diagrams, and pictures is an attempt to facilitate the students in transforming one representation to another representation through the connection between new information and students' prior knowledge. Furthermore, it can also reduce students' difficulties in understanding abstract concepts (Kurnaz and Arslan, 2014; Hill and Sharma, 2015).

Basically, science is the study of nature and its phenomena. To explain natural phenomena that occur, scientists use concepts, rules / laws, propositions, and theories. The students are difficult to learn and to understand science concept because the concept is very abstract, the material is too much and cannot be learned without a good mathematical background (Ornek et al., 2008).

Applying multiple representations in science learning is important effort to achieve general principles of effective pedagogy that can make complex and abstract concepts easier to understand and more enjoyable. The students need to understand the various forms / modes of representation of science concept or process. In addition, students must be able to translate a representation into another representation through the coordination of prior knowledge in order that it can be used in solving problems.

Based on the description above, the use of multiple representations in science learning is highly needed to make science concept easier for students to understand. One of the suitable learning models to use based on multiple representations is problem based learning (PBL) (Jonny *et al*. 2020). PBL is a learning model that presents problems to the students, asks questions, facilitates investigation, and communicates the results of solving problems. The problems studied should be real problems related to everyday life.

2. Research Method

The research method used in this study was a quasi-experimental design with a pre-test-post-test control group (Creswell and Clark, 2007). This research was conducted at one of the state junior high schools in Medan. The sampling technique was using cluster random sampling. The participants of this study consisted of two classes. The first was an experimental class which was treated by implementing PBL based on multiple representations and the second was control class which was treated by implementing traditional learning, 38 seventh grade students of each. The research

instrument was multiple choices, 40 items with 4 options which measured students' conceptual understanding in temperature and heat.

Analysis of data was using t-test with the condition that the data are normally distributed and homogeneous (Howell, 2013). Statistical analysis of data used SPSS for Windows. The significance level was set at 0.05. The level of conceptual understanding test involved categories: interpreting, exemplifying, explaining, comparing, summarizing, classifying, and concluding (Anderson and Krathwohl, 2001).

The effectiveness of implementing PBL model to improve students' science conceptual understanding was determined based on the average normalized gain score (N-gain). The percentage of normalized gain (N-gain) for each student in each group was calculated by using the formula:

$$\text{N-gain (\%)} = \frac{S_{post} - S_{pre}}{S_{maks} - S_{pre}} \text{ x } 100$$

where: N-gain = Normalized-gain
Spost = final test score of students' science conceptual understanding
Spre = initial test score for students' science conceptual understanding
Smax = ideal maximum score

The level of N-gain can be classified as follows: (1) if N-gain> 70%, then N-gain is in the high category; (2) if 30% ≤ N-gain ≤ 70%, then the N-gain is in the medium category; and (3) if the N-gain is <0%, then the N-gain is in the low category (Bao, 2006).

3. Results

Before learning activity was carried out, at the beginning of the study, both classes had been given a pre-test of understanding the concept of temperature and heat, 40 items with four options. The experimental class learning process was carried out by using PBL model based on multiple representations and a control class with traditional learning, six meetings of each. At the end of the lesson, a post-test was carried out.

The results of the homogeneity and normality test of the pre-test and post-test data for both classes were homogeneous and normally distributed. The results of the pretest data difference test for understanding the science concepts of the two classes were the same, in other words there was no difference in conceptual understanding between the experimental class and the control class. After implementing PBL model based on multiple representations in the experimental class and traditional learning in the control class on temperature and heat for six meetings, a post-test was carried out in both classes.

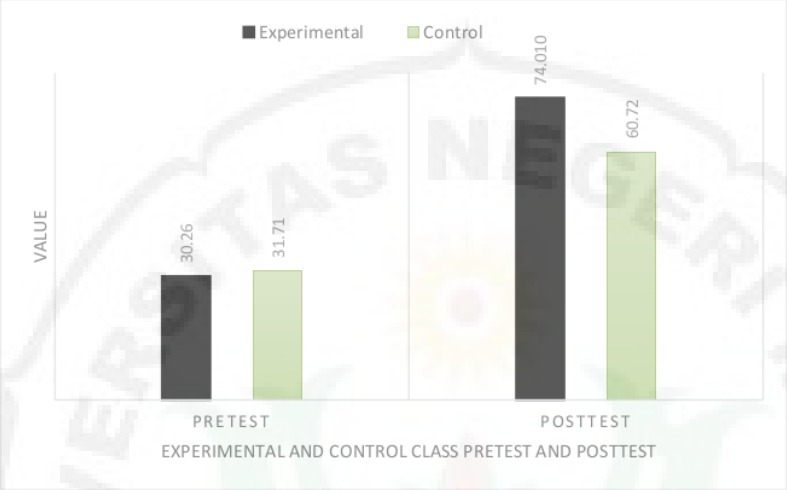

Figure 1. Pre-test and Post-test Data for Experimental and Control Class

The pretest and posttest data for experimental and control class were shown in Figure 1. Based on figure 1, the average pretest understanding of the science concept in the experimental class had an average value of 30.26 and the control class was 31.71. The average posttest for experimental class was 74.01 and control class was 60.72. The understanding of the science concept achieved by the experimental class was higher than the control class, in other words it can be concluded that the application of the PBL model based on multiple representations had an effect on students' conceptual understanding in temperature and heat. Furthermore, the percentage of increasing N-gain conceptual understanding was respectively 42 and 63 for control and experimental class as shown in the figure 2 below. Both were in the moderate category.

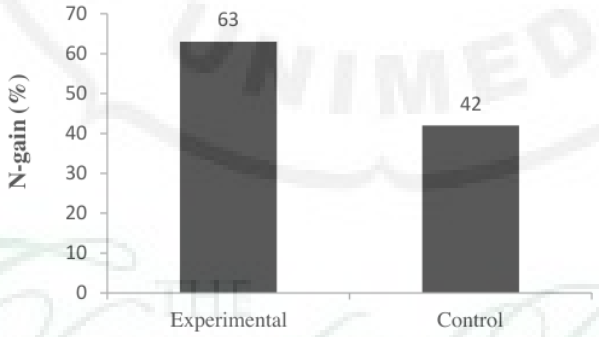

Figure 2. The Percentage of Increasing N-gain Conceptual Understanding for Experimental and Control Class.

The percentage of increasing N-gain in conceptual understanding can be expressed into each component / indicator, namely: interpreting (P1); exemplifying (P2); explaining (P3); comparing (P4); summarizing (P5); classifying (P6); and concluding (P7) which respectively achieved by the experimental class: 68.2; 62.6; 70.3; 65.4; 44.5; 55.7; and 64.8, whereas the percentage of increasing N-gain in conceptual understanding each indicator achieved by the control class was 27.8; 45.4; 41.7;

40.5; 32.5; 45.4; and 34.5 respectively. The highest percentage of increasing N-gain in conceptual understanding component for experimental class was 70.3 (P3) in the high category and the lowest percentage was 44.5 (P5) in the medium category. However, the highest percentage of increasing N-gain in conceptual understanding component for control class was 45.4 (P2 and P6) in the medium category and the lowest percentage was 27.8 (P1) in the low category as shown in the figure 3. The research found that applying PBL model based on multiple representations was more effective in increasing students' conceptual understanding than applying traditional learning (Anas *et al*., 2020).

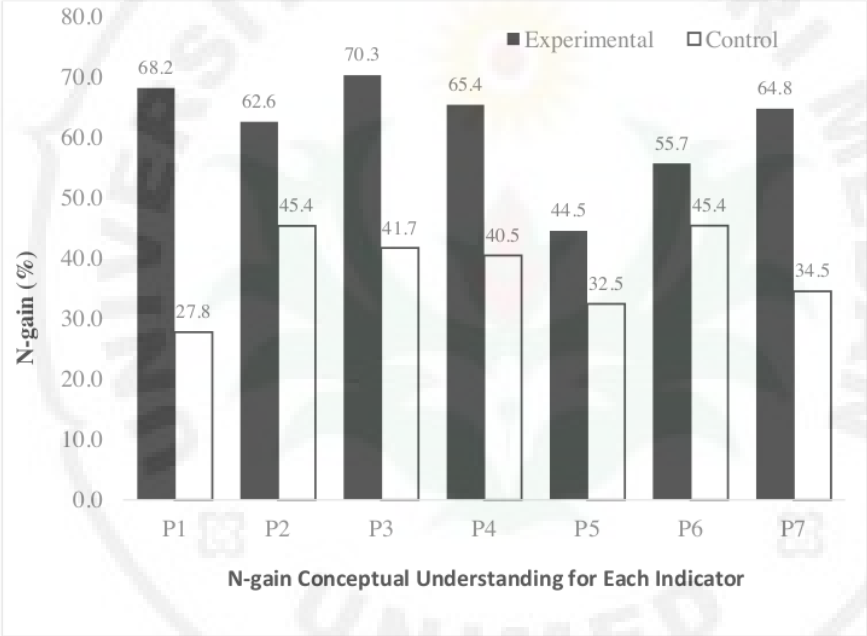

Figure 3. The percentage of Increasing N-gain Conceptual Understanding for Each Indicator.

4. Discussion

In general, the implementation of PBL based on multiple representations includes several stages as follows: 1) The preparation stage, where the teacher prepares lesson plan, learning materials based on multiple representations, and problem-based student activity sheets for six meetings; b) The implementation stage, by applying PBL model based on multiple representations; c) The analysis stage, which includes evaluating and reflecting the difficulties experienced by the students in applying PBL based on multiple representations.

The PBL stage is used to train the students to solve the problem, to organize the students in learning science, to help the students in conducting individual and group investigations, to develop and present their work, and to analyze and evaluate the problem-solving process (Arends, 2012) by using graphs, tables, mathematical equations, and figures (Ainsworth et al., 2011).

Based on the findings of this study, applying PBL model based on multiple representation is more effectively to improve students' conceptual understanding than applying traditional learning. In implementing PBL stages, the teacher acts as a facilitator who presents the problem, explains the learning objectives, and motivates the students to be actively involved in problem solving. The learning is student-driven with the aim of solving the given problem. The problem is presented

verbally that is in the picture, and then the students analyze the problem contained in the student worksheets. The students feel interested on the given problem because it is related to everyday life and they try to solve the problem by finding relevant information that can help the problem-solving process from various references. The learning process must go two-way directions, which means the students are actively asking the questions if they have any difficulties before conducting further investigation. By presenting the problem, the students are more interested to learn and build their self-confidence in solving the problem.

The stage of organizing students to learn, the teacher helps the students to define and organize the learning tasks related to the problem. The students are divided into groups of 4-5 people in order to collaborate in doing further investigation to solve the problems. In this case, they share information and exchange ideas with each other.

On the stage of guiding individual and group investigation, the teacher guides and directs students to gather information from relevant resources, include helps the difficulties occur when solving the problems. In the problem solving process, the students conduct investigation through experiment by following the experimental procedure in the student worksheet. Student worksheets are designed with the questions which direct them to solve the problems. Some of the questions in the student worksheets are in words; some are in the form of tables, pictures, and graphics. There is space for students' answer sheet in the form of tables, verbal, graphs, and mathematical equations. Students in the group are required to play an active role in thinking and expressing the results of their thoughts in order to build a high students' collaboration and students' involvement. Students who work in group try to share knowledge with their fellow students. Through this process, they can construct their own understanding to gain a deeper science conceptual understanding, such as they can present the data in the form of tables or graphs, explain why that is so, provide the examples of the concept application in everyday life, interpret the obtained graphs based on the results of the investigation, classify and compare one another.

This process allows them to have a high teamwork. As Celik et al. (2011) stated that PBL was accepted as one of the most effective learning models in increasing independence, group work skills, curiosity, motivation, inquiry skills, and understanding of the concepts which can improve their science learning outcomes. Furthermore, Celik et al. (2011) stated that if the PBL model was applied more often to the students it would have built them become trained to work in team and well-trained in doing investigation as well.

The next stage is developing and presenting students' work. In this stage, the teacher helps the students make a plan and prepare appropriate work such as report, and then helps them share assignments with their friends. At this stage, the students are required to find alternative solutions in problem solving. They openly and confidently express their ideas, try to find and explain as much as possible.

On the stage of analyzing and evaluating the problem-solving process, the teacher helps students to reflect or evaluate the problem-solving process through investigation. In this stage, the students are required to analyze the data obtained from the results of the investigation. The result of data analysis is presented in words, tables, and graphs. Furthermore, the result is emphasized by presenting mathematical equations. In this case, the students try to analyze their findings, express the ideas in giving response to the problems from other groups, answer the questions, and present their work responsibly, systematically, and regularly. This process makes students' understanding of concepts much stronger.

Through PBL based on multiple representations, the students learn not only to memorize the learning materials but also to experience the meaningful learning. The students are finding and modifying the complex information, checking for the new information and then revising it if it doesn't fit, all by them. This is supported by Martiasari et al. (2016) which states that the application of PBL based on multiple representations in science learning can affect students' conceptual understanding. Heuvelen and Zou (2001) found that learning using multiple representations, especially using graph as a useful visual tool, can help the students to understand the concept of work and energy in solving

related problems (Yakmaci-Guzel and Adadan, 2013). Learning with multiple representations can improve problem-solving abilities (De Cock, 2012). This is supported by Ainsworth (2008) who states that multiple representations have three main functions: supporting, interpreting, and building a more comprehensive understanding.

PBL based on multiple representations has a positive effect on students' science conceptual understanding because multiple representations can build students' understanding by providing complete information from the various forms presented in order to make the deeper understanding of the concepts. Learning with multiple representations can improve students' science conceptual understanding. Furthermore, the conceptual knowledge acquired deeper and lasts longer in the students' brain (Yakmaci-Guzel and Adadan, 2013). This is supported by Kurnaz and Arslan (2014), Hill and Sharma (2015) which state that by presenting multiple representations related to science concepts such as words, mathematical representations, diagrams and pictures can make the abstract concept easier to be transformed from one representation to another, and can also reduce students' difficulties in understanding the abstract concepts.

5. Conclusions

Based on the results of different test, it was found that the application of PBL based on multiple representations had an effect on students' conceptual understanding in temperature and heat. The percentage of increasing N-gain conceptual understanding was respectively 42 and 63 for control and experimental class. Both were in the moderate category.

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