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Improving Student Mathematics Understanding through Problem-Based Learning

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Abstract
This study aimed to improve students' mathematics understanding through Problem-Based Learning. The subjects were Year 8 students in one of the junior high schools in Sigli, Indonesia. The main instrument used in this study was a mathematical understanding test, while the supporting instrument was the observation sheets of student and teacher activities. The data were analyzed qualitatively and described descriptively. The results showed that students' mathematics understanding reached the classical mastery learning of 62.50% and 75.00% for the cycle I and II, respectively. Based on these results, it can be concluded that the ability of mathematics understanding enhanced through the Problem-Based and Learning model.

Keywords: Problem-Based Learning, Mathematics Understanding, Junior High Schools.

One of the paramount mathematics skills for students is mathematical understanding (Soemarmo, 2010). The National Council of Teachers of Mathematics (NCTM) stated that mathematics understanding is critical because conceptual understanding will facilitate students in learning mathematics. Each learning should emphasize further on the mastery of concepts so that students have an adequate foundation to achieve other basic skills, such as understanding, communication, connection and problem-solving. The 2013 curriculum also stipulated that mathematics understanding is the most basic knowledge for studying advanced topics. However, students' mathematics understanding has not achieved optimum results. The research findings of Putra research, Setiawan, Nurdianti, RettadanDesi (2018) stated that students have not yet achieved the mastery learning for mathematics understanding. Rodhi (2018) also found that students experienced difficulties in polyhedra.

The initial observation of students in the school studied revealed that mathematics understanding was lacking. The observation of the learning activities of polyhedra in Year 8 in the school studied, it was found that students required help from others in solving the problems given by the teacher. Students did not try to discover the solution by themselves even though the teacher has tried to guide them. In addition, students did not know the right concept to solve the given problems. Thus, they were bored and seemed lazy to think. Finally, some students submitted a blank paper without trying to give a solution. The results of these observations indicated that students did not have an adequate conceptual understanding.

Djamarah (2010) argued that teachers need to identify problems, including concerning the learning material, learning models, instructional media, and student abilities. Thus, the teacher needs to implement the learning that provides students with the opportunities to be directly engaged in the learning, actively interacting and communicating with their peers and teachers as well as using the media during the learning process.

Problem-Based and Learning approach is one of the learning approach applied to mathematics learning. PBL model connects the relationships between concepts and applies these concepts in daily life. The research finding of Respati, Maulana, and Gusrayani (2016) concluded that PBL learning influences students' mathematics understanding. PBL is related to mathematics understanding. PBL emphasizes the process of student involvement in finding concepts so that it enables to link various concepts in mathematics or other disciplines. It is in line with Fariana's (2016) research which found that PBL models encourage students to find the relationship of the topics studied and real-life situations so that they can develop the necessary and/or sufficient conditions of a concept. PBL encourages students to apply the materials in daily life, meaning that it is in line with the skills to use and select certain procedures.

This research was critical so that mathematics teachers can apply PBL models to improve their teaching strategies to improve students' mathematics conceptual understanding. Students' mathematics understanding will be the foundation for further materials. This research aimed to describe students' mathematics understanding and learning mathematics using the PBL approach in one of the junior high school in Sigli, Aceh, Indonesia.

Method

This research employed a classroom action research (CAR) and involved 24 Year 8 students from one of the junior high schools in Sigli, Aceh, Indonesia. Kemmis& Mc. Taggart in Arikunto (2012) stated that CAR focuses on three main activities, namely (1) Planning, (2) Acting and Observation, (3) Reflection. Planning involved identifying problems in mathematics learning, especially issues related to students' mathematics understanding before formulating these problems. Based on the planning, the PBL learning model learning process was implemented in mathematics learning. The observation was then conducted to obtain an overview of mathematics learning activities through PBL in the classroom.

Data were analysed using descriptive qualitative and comparative descriptive method. Verbal data, observation data of Year 8 students learning using PBL, was analysed using the descriptive qualitative analysis. On the other hand, quantitative data were analysed using comparative descriptive data analysis, namely by comparing the results between cycles.

This study was conducted in two cycles, and each consisted of three stages: planning, implementing, and observing and reflecting. The reflection results from cycle I decided whether cycle II was required. If cycle II was needed, it should be carried out similarly with the steps of the cycle I, and so on. The indicators of the success in improving students' learning outcomes using the PBL model were the number of students experiencing mastery learning (minimum grade of 65), at least 75% of the students in the classroom.

Results

Learning in the Cycle I

The planning stage in cycle I involved designing a lesson plan based on the PBL syntax for the topic of the elements and surface area of cubes and cuboids, Student Worksheet I, and test items for mathematics understanding test of the cycle I and II. In the implementation and observation stage, the teacher provided apperception through questions concerning polyhedra and its examples around students. The teacher motivated students by giving examples related to the area and volume of the cube. The teacher posed questions such as "how do you know if the wrapping paper you will use to wrap the gift will be enough? How do you calculate the costs needed to make the frame of a cube-shaped box?" Furthermore, the teacher informed the learning objectives, that were to solve problems related to the elements, area and volume of the cube, and explained the syntax of learning through the PBL model.

During the core activity, the teacher divided students into four groups of six people. Each group was provided with a student worksheet I consisting of mathematical understanding related to the cubes and cuboids. Student worksheet I was provided to enable students to use the right concepts to solve the existing problems. Each group consisted of students with mixed mathematics performance so that a cooperative atmosphere occurred during the learning process. The teacher instructed students to join the groups determined. The classroom started to be chaotic when students placed themselves in groups. The teacher distributed the student worksheet I to all groups, three copies for each group. The teacher instructed the students to carefully read the instructions and information in the student worksheet I. The teacher also made the group solve the problems given by facilitating the discussion, such as responding questions that they did not understand. The problems in student worksheet I included problems about identifying the elements of a cube, calculating the area of wrapping paper needed and the cost of making the frame of cube-shaped objects.

The teacher checked the results of each group's discussion before they presented the results of the student worksheet I discussion. The first group who completed the worksheet and the most accurate received a reward of additional scores for each student in the group. This reward was teachers' effort to make students more enthusiastic in completing the student worksheet in groups.

At the end of the lesson, all groups presented the results of their group discussions. Once all groups presented the results of their group work, the teacher invited all students to examine the solutions presented. Next, the teacher asked the best group to present their results, followed by the other groups. Each group listened to other groups presentation. During the presentation, students asked questions such as how to obtain the solutions and formulas applied. The teacher posed some questions to draw conclusions about concepts, such as the relationship between the width and volume of the cube and its application to everyday life problems.

The results of the student worksheet of three of the four groups fulfilled the indicators of mathematics understanding. Thus, it can be concluded that the second cycle was needed. In the reflection stage, findings of the first cycle were analyzed, including how the teacher did not manage to cover all questions posed by students, so in the second cycle, the teacher needed to coordinate student questions by responding the similar questions once only. Also, teachers should pay more attention to students who experienced difficulties in solving problems.

The Learning in Cycle II

At the planning stage, the teacher developed a lesson plan based on the PBL syntaxes for the topics of area and volume of the cuboid. More interesting and real pictures, different from cycle I, were added to the lesson plan in cycle II. The teacher also prepared the student worksheet II and test items for cycle II. At the implementation and observation stages, the teacher initially conditioned the students to learn about the area and volume of the cuboid. The preliminary activity carried out by the teacher was to put more effort in apperception that led students to recall materials studied previously, namely the elements, area and volume of the cube. The teacher motivated the students about the importance of elements, area and volume of the cuboid in daily life, such as counting the number of cube-shaped objects in a box and determining the frame length of cuboid-shaped objects. Finally, the teacher told the students the objectives of understanding the concept of elements, area and volume of the cuboid.

In the core activity, the teacher administered the student worksheet II to the groups. Students began to draw shapes of cubes and blocks to solve problems concerning the number of cubes to fit into a block box. Next, students analyzed the size of the cube calculated using the concept of the volume of the cube and then calculated the volume of the cuboid for comparing it to the volume of the cube determined. The result became the response to the number of cubes to fit into a block box. In the discussion, students also used a mathematics textbook to work on student worksheet II.

Students read and understood the student worksheet II by discussing and exchanging ideas with the group members. Some students asked the teacher for the concepts they did not understand. Students understood the instruction of the problem about the costs required related to the area of the cuboid. The students needed to use facts with the existing images to deduce the concepts correctly. The teacher strived to respond to the students' questions so they could understand well. The classroom atmosphere was good because students were accustomed to collaborative learning in a group. The teacher walked around the classroom to ensure the student group discussions run smoothly and directed students who had questions regarding the student worksheet II. Some students asked about the problem in the student worksheet II, the concept of cuboid volume. The number of cubes in the cuboid was based on the unit volume, and then it is concluded to obtain the formula of the cuboid volume. On the other hand, the cuboid surface area was calculated from the rectangular sides, part if of the cuboid net.

At the end of the lesson, each group presented the student worksheet II that had been completed. The teacher asked all groups to recheck the solutions on the student worksheet II. Overall, the results of the student worksheet II showed that students did the student worksheet II well. In other words, it can be said that students' mathematical understanding was enhanced through PBL learning.

In the reflection stage, the teacher made better efforts. The teacher organized student questions well so that the questions representing other questions could be addressed. The results of students' understanding in the second cycle fulfilled the performance indicators, and so it was unnecessary to repeat the next cycle. Once each cycle I and II learning had been completed, a cycle test was administered. The test aimed to determine students' mathematical understanding. The results of the cycle I and II tests can be seen in Table 4.

Table 4: Mathematical Understanding Test Results of Cycles I and II

Number	Score	The Number of Students	
		Cycle I	Cycle II
1	44	7	5
2	56	2	1
3	67	8	3
4	78	5	8
5	89	2	7
Average		63.43	71.76
The percentage of classical mastery learning		62.50%	75.00%

In cycle I, nine students did not achieve the minimum classical mastery learning criteria. Whereas in the second cycle, only six students scored the minimum classical mastery learning criteria (below 65). The average test score of the cycle I and II indicated the improvement of students' mathematical understanding, from 63.43 in cycle I to 71.76 in cycle II or increased by 8.33. The percentage of classical mastery learning also increased from 62.50% to 75.00%. These results showed that PBL learning models could improve students' mathematical understanding.

Discussion

Mathematics understanding is one of the objectives of learning mathematics. The understanding of concepts directs students to discover solutions and solve problems. The analysis results of the first cycle mathematics understanding test illustrated that students still experienced difficulties in solving the given problems. The first cycle test showed that students have not yet reached criteria of classical mastery learning, where the average percentage achievement for all indicators was 62.50%, below the minimum criteria.

Based on these results, researchers took some actions to apply in cycle II to improve students' mathematical understanding. The teacher facilitated students in understanding the concepts by (1) understanding and identifying the problems by listing what is known and asked, (2) determining the formula leading to the question, and (3) calculating. Powerpoint media was also used in cycle II so that students were more attentive and enthusiastic when the teacher explained. The teacher also paid more attention to students whose scores were below the minimum mastery learning criteria by providing more intensive learning. After the teacher explained the materials in cycle II, students who found some difficulties were given scaffolding of these difficulties.

The analysis results of the mathematical understanding test in cycle II illustrated the increase in mastery learning outcomes during cycle II. The number of students who achieved the mastery learning increased from 15 students in the first cycle to 18 students in the second cycle, with an average value of above 65. The classical mastery learning also rose from 62.50% in the first cycle to 75.00% in the second cycle. The analysis results of the achievement indicators of mathematical understanding showed that the score of the students' answer assessment was dominated by scores two and three. The results decided that it was unnecessary to proceed to cycle III.

One of the advantages of the PBL model is that it can improve students' mathematical understanding. Students understood the concepts of the materials studied and engaged actively in creating ideas for solving problems. The effort made by the teacher in this study was based on the Problem Based Learning (PBL) model syntax, namely the first stage of the PBL model, namely the orienting the students to the problem, with the efforts made by the teacher, which was orienting the problem so that students can understand the concept to achieve the learning goals. The teacher also motivated students by displaying images concerning events related to the material in everyday life.

The first stage in the PBL model was the teacher orienting students to the problems. The second stage was organizing students to learn; the teacher organized students in the classroom by asking questions about students' daily activities related to the materials discussed, providing opportunities for students to present their opinions about the importance of the materials and allowing students time to discuss the student worksheet provided. The activities in this stage are useful for developing students' understanding so that they can relate to some ideas or concepts previously learned.

The third stage in the PBL model was guiding individual and group investigations, where the teacher provided students with problems to discuss in a group and with opportunities to obtain the right solutions. The fourth stage was developing and presenting the work; the teacher posed questions to lead students to understand the concepts and find ideas for solving the problems. The teacher also facilitated students who had difficulty in understanding mathematics. Lastly, the fifth stage was to analyze and evaluate the problem-solving process; the teacher asked the students to present their work and conclude the results using the correct concepts.

The teacher also provided examples related to students' life, so the students can easily understand concepts related to real-life problems. These efforts aimed to improve students' mathematics understanding. It is in line with the findings of Andayani (2017), and Lestari and Surya (2017) which concluded that the PBL model stimulates students' thinking by linking the problems with the right concepts.

The improved indicators of mathematics understanding were the indicators of using the relationship patterns to analyze, make analogies, generalize, and arrange and test the conjectures. This improvement was due to the teacher's efforts in providing problems with real contexts, so students could determine the right concepts in solving problems. This is in agreement with Supriatna, and Afriansyah (2018) who reported that the PBL model develops students' understanding of concepts in solving problems in daily life. Furthermore, Abrar's research (2016) also revealed that the PBL model could create a framework for linking several concepts.

After the first and second cycles, some improvements were noted. In cycle I, the students' mathematics understanding was underdeveloped. In cycle II, students began to solve the problems the student worksheet II independently. It was in contrast to cycle I, where students were a bit lazy to solve the problems in the student worksheet. The situation significantly changed in cycle II; students were more familiar with the PBL model. Students' dependence on teachers and friends decreased in cycle II, and students had a better teamwork skill by jointly solving the student worksheet. The interview revealed that students felt better through the application of the PBL model. They could learn the material and understand the concepts taught. They were also enthusiastic for the PBL model. Thus PBL learning improved the students' mathematics understanding, as proven in cycle II where the students achieved the classical mastery learning above 75%. These results are consistent with Aripin (2015) and Annagih, Yuwono, and Sulandra (2017), who concluded that the PBL model enables students to improve their mathematics understanding.

Conclusion

Based on the results and discussion concerning the improvement of students' mathematics understanding through the PBL model, it can be concluded that the students' mathematics understanding on the topic of cubes and cuboids at the school studied were improved through the PBL model. This is indicated by the increase in classical mastery learning from 62.50% in the first cycle to 75.00% in the second cycle.

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