The application of problem based learning model to improve mathematical cognitive skill and students engagement toward curved-face three-dimensional objects in IX grade of SMP Laboratorium Percontohan UPI

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Abstract. As an effort to improve the quality of learning in the classroom, a teacher needs to consider an effective and appropriate learning model, so that it can develop mathematical cognitive skills and student’s engagement. A learning model issued in this investigation is Problem Based Learning (PBL), which is implemented to IX grade students of SMP Laboratorium Percontohan UPI. This investigation is aimed to (1) measure, (2) find out the improvement process, and (3) improve mathematical cognitive skill and student’s engagement toward curved-face three-dimensional objects using PBL model. The result of this investigation shows that the mathematical cognitive skill and students’ engagement can be improved. The average score test in cycle I is 69.9, then 81.7 in cycle II and become 85.8 in cycle III. Furthermore, this PBL model is able to improve the student’s engagement and accomplishment. In cycle I, the student’s accomplishment reach 34.37%, in cycle II reach 75%, then reach 90.625% in cycle III. From these results, the investigator concluded that PBL model can improve students’ mathematical cognitive skills and engagement. Therefore, the investigator suggests that the PBL model can be applied by teachers to other materials dan used as an alternative in learning mathematics at school.

1. Introduction
Education is not only one of the most significant sectors for a nation sustainability and also an important indicator which shows the advancement of a country. Indonesia, as a developing country is obviously longing for a passion to improve its nation and country by working on their quality in terms of education. The better the quality itself the greater nation will be. It is stated in [1] that “Education is a conscious effort and patterned to manifest a learning atmosphere and process to allow the learners actively develop their potential to acquire religious strength, self-control, character, intelligence, attitude as well as set of skills required for themselves, society, nation, and country.”

One of the efforts to reach the goal of education is through educational quality improvement that can be conducted through learning activity. The quality improvement in education means the quality improvement of nation-building in the present or even in the future. According to Suryadi human resource that is expected
to be able to deal with the challenge is one who can have critical, logical, systematic, and creative thinking so that allows them to cope with challenge independently and confidently [2]. The attitude and cognitive skills mentioned above can be developed through Mathematic because it has not only strong and clear relationship between its concept and also able to develop cognitive skills.

Turmudi stated that Mathematic strongly relates to the daily life. Thus, as soon as possible students’ will be able to apply Mathematic in a useful context for them, whether it is useful in their daily life or even in their professional world. Besides, learning Mathematic makes someone accustomed to thinking critically, logically, and improving their creativity. Standing out to become more important in daily life, mathematic is considered as human activity [3].

Students confront various problem in their daily life many times. They deal with easy or even complex problems related to Mathematic. Therefore, students need to be equipped with sufficient knowledge to solve those problems. At school, the students need to be given a lot of opportunity in exploring more and experimenting the material, so that the students are able to solve the problem based on their acquired knowledge.

The students’ quality improvement in Mathematic can be achieved if the quality of learning in the classroom is well conducted and conventional method can be avoided. on the other hand, the learning activity should be student centered. Conventional method is undoubtedly still used by the teacher in a learning activity. Students get more explanation from the teacher, the teacher gives the example and the answer, the students take note, and the students are allowed to ask if they don’t understand then perform the exercises.

Based on Mathematic contents of standard published by Depdiknas for all level in elementary and intermediate, Mathematic is aimed to [4]: (1) Understand the Mathematic concept, explain the relationship between the concept, and apply the concept or algorithm, accurately, efficiently, flexibly, and precisely in solving the problem; (2) Use the cognitive skills toward pattern and properties, conduct Mathematic manipulation in generalization, collect evidence, or explain ideas and Mathematic statement; (3) Solve the problem which covers the ability to understand the problem, design Mathematic model, complete the model, and measure the acquired solution; (4) Communicate the ideas using symbol, table, diagram, or other medias to clarify the situation or problem; and (5) Possess the attitude to appreciate the use of Mathematic in daily life such as, curiosity, attention, interest in learning Mathematic, tenacity and confident in solving problem.

The Aims of Mathematic mentioned above, the students are expected to possess cognitive skills, conduct Mathematic manipulation, create generalization, collect evidence, communicate, and improve Mathematical disposition after learning mathematic. Beside The students’ Mathematic skills, the students’ engagement is considered as an important part as a means to develop their ability to perform learning activity so that enables them to solve the problems in their daily life.

Mullis stated: “Reasoning mathematically involves the capacity for logical, systematic thinking. It includes intuitive and inductive reasoning based on pattern and regularities that can be used to arrive at solutions to non-routine problems” [5]. Thus, cognitive skills which covers to think logical and systematic can be solved to reach the non-routine problems.

The importance of developing Mathematical cognitive skills towards Junior High School (SMP) Students also revealed in NCTM as follows: “Reasoning is an integral part of doing mathematics. Students should enter the middle grades with the view that mathematics involves examining patterns and nothing regularities, making conjectures about possible generalizations, and evaluating conjectures. In grades 6-8 students should sharpen and extend their reasoning skills by deepening their evaluations of their assertions and conjectures and using inductive and deductive reasoning to formulate mathematical arguments. They should expand the audience for their mathematical arguments beyond their teacher and their classmates” [6].
In Intermediate class, NCTM stated the importance of cognitive in Mathematic subject. Mathematic learning also aims so that the students are able to (1) evaluate the pattern and structure in detecting regularities, (2) formulate the generalization and conjecture the observation’s result of regularities, (3) evaluate conjecture, and (4) construct and evaluate the Mathematical argument. By conducting the referred learning objectives, it is highly expected that the Mathematical cognitive skills can be acquired by the students [6].

In line with NCTM, Wahyudin argued that cognitive and substantiation should become permanent part of Mathematical experience against the students since early childhood to 12 grades [7]. Mathematical reasoning is a custom of thoughts, and just like other customs. This should be established through continuity in various context.

In Understanding various Mathematic problems at school, so the investigator conducts the observation and interview toward Mathematic teachers in SMP Laboratorium Percontohan UPI. Based on the result of discussion and interview with the subject teachers, it is obtained that the students often experience the difficulty in solving Mathematic problems which requires reasoning or cognitive skills. The students acquired the tendency in solving routine problems in Mathematic, counting and resolving questions that only requires the ability to solve those problems in such mechanistic ways. Some difficulties engaged by the students are usually occur in essay questions which once again requires reasoning or cognitive skills. Besides that, the students’ engagement aspect is considerably low.

According to Dictionary of Indonesian Language Kamus Bahasa Indonesia Active/engage means industrious (work over and strive, meanwhile engagement is things to do to become actively involve) [8]. Meaningful learning process is a process which involves various activity in learning toward the students. Therefore, teachers should perform several attempts to motivate the students’ involvement in learning activity. Furthermore, the level of students’ involvement in a learning process should be considered as an indicator in determining the quality of the learning itself. Thus, innovation is required to be implemented by the teachers to overcome, to motivate, and to improve the students’ involvement in learning.

Based on the result shown in observation and interview with the subject teachers, reflection toward the learning process conducted to perform classroom action research is required by the investigator in improving the students’ Mathematic reasoning/cognitive skill and also the students’ involvement towards the chapter of curved-face three dimensional objects. The learning process which is provided in this investigation used Problem Based Learning model that is specially designed to allow the students obtain meaningful and important knowledge which makes them adept in solving the problems.

The problem or the issue given in PBL learning model is best contained: complex, ill structured, open ended problem, and authentic. The general phases should be through as follows: orienting the problems to the students, organizing the students, guiding the individual and group investigation, developing and presenting the solution, analyzing and evaluating the process of problem solving.

According to the background elaborated above, the investigator performs the classroom action research entitled: “The Application of Problem Based Learning Model to Improve Mathematical Cognitive Skill and Student's Engagement toward Curved-Face Three-Dimensional Objects in IX Grade of SMP Laboratorium Percontohan UPI”

The Aims Of The Investigation. In improving the quality of mathematic learning in IX grade SMP Laboratorium Percontohan UPI, then the investigation is aimed to: (1) Measure the Mathematical reasoning or cognitive skill and engagement of the students in IX grade SMP Laboratorium Percontohan UPI toward the chapter of curved-face three-dimensional objects by using Problem Based Learning model; (2) Identify the improvement process of Mathematical reasoning or cognitive skill in IX grade SMP Laboratorium Percontohan UPI toward the chapter of curved-face three-dimensional objects by using Problem Based Learning model; (3) Identify the value of the Improvement in mathematical reasoning or cognitive skill and
students’ engagement conducted in IX grade SMP Laboratorium Percontohan UPI toward the chapter of curved-face three-dimensional objects by using Problem Based Learning model.

2. Methods
The method used in this investigation is analytical descriptive through Classroom Action Research. A particular study that is used to collect data, describe, organize, analyze, conclude, and measure the obtained data so systematic description can be acquired.

2.1 Subject and Location
The classroom action research is conducted in SMP Laboratorium Percontohan UPI Bandung. The subject of this investigation is 32 students from IX grade. The class selected in this study as an investigation subject is considered as a class that academically required to be improved in terms of mathematic reasoning or cognitive skills, learning result, and their engagement. Furthermore, Problem Based Learning model is selected as a treatment for the subject.

2.2 Investigation Instrument
In obtaining the required data by the investigator, the instrument is needed in collecting data such as follows: Competency try out (cycle test), students’ engagement and teachers’ involvement observation sheet.

2.3 Investigation Procedure
This classroom action research is performed through four phases in accordance to John Elliot model which is started from planning, performing, observating and reflecting [9]. The flows of the performed action can be seen in the figure 1 as follows.

![Figure 1. The Implementation Flow of Classroom Action Research Based on John Elliot’s Model.](image)
Based on the analysis of learning materials and the condition of students, in this study was conducted in three learning cycle which consists of two cycle of PBL learning and one cycle test. In each learning cycle, the stages of classroom action research were planning, implementation of action, observation, and reflection.

2.4 Analysis Of The Data
Data processing in this research was gained by data based on observation of student activity sheet, teacher activity sheet and competency test data (cycle test). Observation data result was analyzed by changing the data into percentage for each observed activity, while data of competency test result was analyzed based on assessment criteria that have been made. Data analysis used in this research was quantitative technique in the form of calculation and qualitative technique in the form of description. After the data collected and checked, when it meets the requirements, then the data was tabulated in the table that was ready for processing and then calculated the percentage.

3. Results and Discussion
From the result of mathematics learning process by using problem-based learning model (PBL) and the evaluation of learning was done, then the writer use the evaluation result to find out whether the learning of mathematics by using problem-based learning model (PBL) can improve mathematical reasoning skill of student of class IX-B SMP Laboratorium Percontohan UPI. Table 1 shows the data of students’ mathematical reasoning or cognitive skill gained from the results of cycle I, cycle II and cycle III.

| Assessment of Research Results | Cycle I | Cycle II | Cycle III |
|--------------------------------|---------|---------|-----------|
| Mean                           | 69.9    | 81.7    | 85.8      |
| Lowest score                   | 35.6    | 46.7    | 46.7      |
| Highest score                  | 95.6    | 100.0   | 100.0     |
| Students who meet the standard | 11      | 24      | 29        |
| Students who don’t meet the standard | 21    | 8       | 3         |
| Mastery percentage             | 34.37   | 75.00   | 90.625    |
| Below standard percentage      | 65.63   | 25.00   | 9.375     |

Based on the results of research during three learning cycles in improving students' mathematical reasoning skill on the chapter of curved-face three-dimensional objects, it can be seen that starting from the implementation of learning cycle I to learning cycle III has shown the improvement in the learning process of mathematics by using problem-based learning model (Problem Based Learning). During the learning cycle I, cycle II and cycle III teachers and observers always carry out reflection after the implementation of learning. From the results of the first cycle test shows that there are still many students who got the score below the standard, after the evaluation, it was found that the learning process needs to increase student activity or engagement in learning and also teachers should be able to arrange learning in accordance with the time allocation based on teaching design. In addition to improve the learning process, in the next cycle, Student Activity Sheet (SAS) was used in order to encourage students to be actively involved in reasoning/cognitive and discussion in solving the problems given by the teacher.

In the second cycle, the students are getting used to the learning process and the students are getting challenged with the reasoning problems given. After conducting the evaluation, this cycle obtained the results of that the mean has increased from the previous cycle. In addition, the students' learning mastery level is increasing, but some students have not shown any significant improvement. In terms of student activity in learning, student result showed improvement and students have become accustomed to finish the
learning process. Based on the things done in cycle II, based on the evaluation and study with the observer, the next cycle learning is going to increase the activity and students’ activeness in the learning then the students are given the opportunity to visit the work to other groups.

In the third cycle of student learning activities increased by using SAS which provides more opportunities for students to explore in learning. Apart from that the real objects in the form of citrus fruit and watermelon was help students to get better understanding in solving the problems given by the teacher that related to the learning materials to find the formula surface area and volume of the ball. Furthermore, in the learning process of the next meeting, the students are given the opportunity to solve the problem to build the curved side room which gives the students an opportunity to improve their reasoning/cognitive skill.

Based on the previous discussion, it can be concluded that there have been several improvements related to the student activity in mathematics learning that which can be seen from the learning result. The mean of the improvement of learning result from cycle I, cycle II and cycle III are presented in figure 2.

![Figure 2](image1.png)

**Figure 2.** The Improvement of Students’ Score Mean from Each Cycle

Based on figure 2, it was found that in the cycle I the students’ mean score was 69.9 increases up to 81.7, in cycle II it increases again up to 85.8 in cycle III. Meanwhile, the data of the lowest and highest achievement of students in each cycle is illustrated in figure 3 below.

![Figure 3](image2.png)

**Figure 3.** The Improvement of the Students’ Highest and Lowest Score in Each Cycle.
From figure 3, it was found that the lowest score in cycle I was 35.6 and then increased up to 46.7, in cycle II and on cycle III the students’ mean score did not increase stay in 46.7. Furthermore, the highest value in the first cycle is 95.6 then in cycle III the highest value was still the same as the cycle II of 100. From the results of the highest and lowest values seen that the value increase in cycle I to cycle II. Although the second and third cycles show the same result, the highest value data in the third cycle is greater. This shows that the application of Problem Based Learning model on mathematics learning is suitable to be implemented in curve-faced three-dimensional object material.

In addition, beside the improvement of student scores mean, the use of Problem Based Learning model can also increase the percentage of students' learning mastery as presented in figure 4 below.

**Figure 4.** The Improvement of the Students’ Highest and Lowest Score in Each Cycle.

Based on figure 4, it is found that in the first cycle only 34.37% or 11 students who got the score above the standard is set, then in cycle II the students’ score increases up to 75.00% or 24 students who got the score above the standard. Furthermore, in the cycle III students’ score increased again up to 90.625% or 29 students who got the score above the standard.

Student activeness/engagement data shows that in cycle I student activity on enthusiasm in learning aspect showed that 21.90% the students were active, 68.80% student were active enough and 9.40% were not active. In the aspect of the students’ courage to ask, it was found that 15.6% students were active, 56.30% of students were quite active and 28.10% were not active. After the teacher improves the learning based on the results of reflection in the first cycle, the cycle of student activity on the enthusiasm of learning shows that 50.00% students were active, 90.00% were quite active and 00.00% were not active. In the aspect of students’ courage to ask, it was found that there were 34.00% students were active, 56.30% of students were quite active and 9.30% were not active. Furthermore, re-evaluation of learning cycle II which was continued by improving learning in cycle III. Data obtained from the learning result of cycle III shows that students’ activeness on the aspect of enthusiasm in learning were 93.75% students were active, 6.25% student were active enough and 00.00% were not active. In the aspect of students’ courage to ask, it was found that there are 65.62% active students, 34.38% quite active students and 0.00% inactive students.

With the number of students who actively involved in the learning process, it can be said that the teacher while implementing the teaching and learning of curve-faced three-dimensional object using the problem-based learning model (PBL) has successfully involved students in learning.
The data of the teacher activity in cycle I generally is good enough, but there are some components that are considered need to be improved by the observer is the teacher’s ability in implementing the problem-based learning model (PBL) that has not been as optimal as the expectation so that in cycle I there are still students who are not active in learning. The deficiencies in cycle I are then fixed in cycle II. In cycle II students are more active in learning and teachers try to keep motivating students to take an active role in learning. After doing the reflection together with the observer, for improvement in cycle III, besides the reinforcement of the material, it is redesigned the learning that motivates the students by using visual aids and real objects that support the learning. Apart from that the classroom and classroom discussions are sharpened understanding of the concept of the material and in order to increase student activity in learning visiting the creation is conducted. From the results of the observations on learning cycle III of teacher and student activity, it can be concluded that the result is better when compared with the result from the previous cycle learning.

The learning outcomes and the improvement student’s activity in learning was happened because teacher use problem-based learning model (PBL). This learning can make group collaboration more active and effective. In addition, the teaching materials that are used can improve students' mathematical reasoning abilities. Thus, problem-based learning can be used as an alternative learning to improve students mathematical reasoning abilities or other mathematical skills.

4. Conclusion
Based on the results of the research that has been done in SMP Laboratorium Percontohan UPI class IX-B year 2017/2018, the ability of mathematical reasoning/cognitive and student activeness on the subject of mathematics for the chapter of curved-face three-dimensional object after using problem-based learning model (PBL) show a positive result.

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