Learning design using problem based learning on topic volume cuboid in junior high school

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Abstract. This study aims to describe the learning process using Problem Based Learning (PBL) on topic volume cuboid. The type of research used is qualitative research with research methods is design research. The subject of this research is the eighth grade students of Junior High School State 3 Prambanan, amounting to 16 students. The stages carried out in this study are the initial design and implementation of learning. The steps used in data analysis are data reduction, data display and conclusion drawing or verification. In this study, researchers developed Hypotetical Learning Trajectory (HLT) on topic volume cuboid using PBL. The results of this study indicate that the learning process goes well according to the HLT that the researcher designed follow the stages of Problem Based Learning and the use of Problem Based Learning can support students in understanding the volume cuboid.

1. Introduction

Based on interviews with grade 8D math teachers at Junior High School, researchers obtained information that there were not many learning models applied in schools and still conventional. This is because the teacher is new and she is in the process of adaptation. Mathematics learning outcomes of students in junior high schools are still lacking. Students tend to pass questions that require problem analysis. During learning, students often wait for the teacher to explain or wait for friends to work in front of the class. Students are less independent and tend to need a relatively long time to study. Study time at school becomes less effective. Thus, student learning independence becomes one of the important things for learning success. With learning independence, students can learn without having to wait or depend on certain learning resources.

The learning model applied makes students tend to be passive so that the learning process becomes less conducive. This is because the teacher is only focused on explaining the topic in front of the class which makes students have to be quiet and listen to what is explained. In addition, the lack of attention to students makes them feel bored with learning that is taking place. In the end, students tend to memorize formulas or topic presented by the teacher. So that, the learning process that takes place is still not optimal.

Based on the results of interviews with the teacher it was also known that, the teacher had never designed a learning process such as HLT but instead used the RPP and syllabus that had been prepared before the learning process began. So that the desire arises from researchers to design a learning process at the school, to see student responses, possible student answers and how students think. It all becomes important for a teacher to guide and assist students.

According to Trianto Problem-based teaching has been known since the era of John Dewey, which now begins to translate into people who are capable and provide the best for them to do inquiry [6]. According to Dewey learning is the interaction between stimulus and response, the relationship between two learning directions and the environment. An environment that provides assistance and

solutions, while a system that serves to help people who are effective can be investigated, assessed, analyzed and sought understanding properly. Student experience gained from the environment will produce material that can be used as a reference and learning objectives [6].

According to Tan problem based learning is an innovation in learning because in PBL students' thinking skills are truly optimized through a systematic group or team work process, so that students can empower, hone, test, and develop their thinking skills continuously [1]. Viewed from the perspective of learning psychology, this learning model is based on cognitive psychology rooted in the assumption that learning is a process of behavior change thanks to experience. Through this learning model students can develop intact, meaning not only cognitive development, but students will also develop in the fields of affective and psychomotor automatically through the problems faced. Problem based learning model takes cognitive psychology as its theoretical support. The learning focus on this model emphasizes what students think as long as they are involved in the learning process, not on what they do in the learning process.

Problem based learning consists of five stages starting with the teacher introducing students to a problem situation and ending with the presentation and analysis of student work. Concisely the five stages of PBL learning are as in the following table:

Table 1. Stages of Problem Based Learning (Source: Richard I. Arends [3])

Stages	Teacher's Activity
Stage 1 Give orientation to the problem to students.	The teacher discusses learning objectives, describes important logistical needs, and motivates students to be involved in problem solving activities.
Stage 2 Organizing students to research.	The teacher helps students to define and organize learning tasks related to the problem.
Stage 3 Assist independent and group investigations.	The teacher encourages students to get the right information, conduct experiments and find explanations and solutions.
Stage 4 Develop and present artifacts and exhibits.	Assisting students in planning and preparing appropriate artifacts (reports) such as reports, models, and helping them to convey them to others.
Stage 5 Analyze and evaluate the problem solving process.	Helping students to reflect or evaluate their investigations and the processes they use.

Based on the fact, researchers tried to solve this problems in order to help students so they can have better understanding and construct the concept about the volume cuboid using PBL approach. The research question in this research was how the learning process using Problem Based Learning (PBL) on topic volume cuboid?

2. Research Methods

The type of research used is qualitative research with the method used in this research is design research method. Gravemeijer and Van Eerde [4] state that design research is a research method that aims to develop Local Instruction Theory (LIT) in collaboration between researchers and educators to improve the quality of learning. There are two important aspects related to research design, namely Hypothetical Learning Trajectory (HLT) and Local Instruction Theory (LIT).

According Akker, Gravemeijer, Mckeney, and Nieveen, design research can be characterized as [5] : (1) interventionist; the reaserch leading to the design of an intervention in the real world, (2) iterative; the the research incorporates a cyclic approach to the design, evaluation, and revision, (3) process-oriented; a model of research that avoids the measurement of inputs and outputs, focus on understanding and improving interventions, (4) oriented to usability: the benefits of design were measured by looking at the practically of the design for the user in reality, and (5) oriented to the

theory: design (at least partially) made by theories that already exist, and field testing of the design contribute to the development of the theory.

The stages carried out in design research are as follows: (1) Preliminary design. The main purpose of this stage is to develop a sequence of learning activities and design instruments to evaluate the learning process.; (2) Design experiments. The stages of design experiments are divided into 2 (two) stages, namely teaching experiments and pilot experiments. In this study, researchers did not conduct teaching experiments.; (3) retrospective analysis. After the design experiment in learning, data obtained from classroom learning activities were analyzed retrospectively.

This research was carried out at Junior Hight School State 3 of Prambanan in VIII grade academic year 2017/2018. The study was conducted in March - April 2018. The research subjects were students of class $VIII^D$ Junior Hight School State 3 of Prambanan with a total of 16 students. While the object of research is the process of problem based learning.

Data collection methods used are written tests, interviews and documentation. In this study the data analysis technique adopted the theory of Salim & Forman [2] is data reduction, data display, and conclusion drawing or verification.

3. Result & Discussion

The learning is carried out on Thursday, March 21, 2018 for 3 lesson hours (3 x 40 minutes). The purpose of this meeting is that students can determine the volume of the cuboid. The collected data resulted in learning trajectory in the topic volume cuboid in class $VIII^D$ which was obtained through several stages, including research preparing for the experiment, teaching experiment, and retrospective analysis.

The teacher conditions the class to begin learning, the delivery of learning objectives, the outline of the scope of the topic & activities to be carried out and reviewing the topic previously studied relating to the topic volume cuboid. The following is an excerpt of some interactions between teacher and students during class:

Teacher: Today we will learn about the volume of the cuboid, therefore please prepare the equipment so that we can start learning. Who can still remember the difference between cubes and cuboid? Can be by example or words.

Student: The cube is a three-dimensional space constrained by six square congruent sides, while the cuboid is a three-dimensional space formed by three pairs of squares or rectangles, with one pair of different sizes.

Teacher: For example cubes and cuboid?

Student: If the cube is a cardboard box for example, the cuboid for example is a speaker pack (the sauce shows).

Teacher: Then, what about the elements in cubes and cuboid, can you still remember?

Student: If the cube has 6 sides, 12 ribs, 8 corner points, 12 diagonal fields, and 4 diagonal spaces. Whereas the cuboid also has 6 sides, 12 ribs, 8 angle points, 12 diagonal fields and 4 diagonal spaces.

3.1. Stage 1: Student Orientation to Problems

At this stage, the teacher gives real problems to students, the goal of which is that students can find the formula of the volume cuboid. Solving the problem using props. The following problem is given to students:

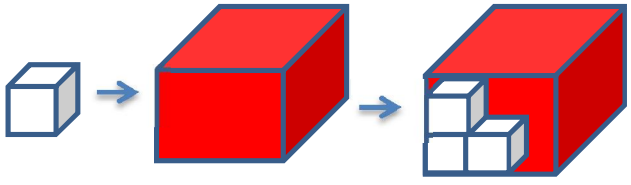

Figure 1. Ilustration Of Manipulative Volume Cuboid

Problem I

Props are provided in the form of cuboid and unit cubes as shown above. The cube will be inserted from Figure 1 with the size of 1 unit into the cuboid.

a. How many cubes do you need to fill the cuboid untill full?

b. Explain the relationship between length, width and height of the cuboid!

Problem II

12 unit cubes are provided.

a. Determine the size of the length, width and height of the cuboid that may be formed from the cubes!

b. What relationship can you conclude?

The following interactions occur between the teacher and students as long as the teacher provides an explanation of the problem to be discussed in the group.

Teacher: Next, sir has 2 problems. You will work into groups. Pay attention to these problems, is there anything that has not been understood from the problem?

Student: What is the conclusion in number 2 sir?

Teacher: So, you will be given teaching aids that will be divided into each group to find answers to the problems given. After finding the next answer what can you conclude from your work.

3.2. Stage 2: Organizing Students for Learning

At this stage, students (with the teacher, if needed), begin planning an inquiry into the problem. At this stage, students are asked to find out what things should be done, and what knowledge is needed to solve the problem. Furthermore, the teacher divides students into groups so that students can work together in groups to find answers to the problems given. The following interactions occur when organizing students to learn:

Teacher: Based on what we have discussed earlier in this lesson, you will use these information to solve the problem given. Next, please divided into groups consisting of 4 groups.

Student: How is the division of the group sir?

Teacher: Please make a group of 4 people. Can be with friends beside and behind. After forming in groups, the pack will distribute teaching aids so that each group uses the problem to be solved.

Student: well sir.

3.3. Stage 3: Guiding Individual and Group Investigations

The teacher as the facilitator sees students by walking around when they are working on the problem. In the first activity, each group fills the unit cube into the cuboid that has been provided.

Figure 2. Group Activity Inserting a Unit Cube Into a Cuboid

From the picture above, the teacher gives support to students to calculate the unit cube needed to fill the cuboid to the full and explain the relationship with the length, width, and height of the cuboid. Following are the results of group discussions on problem I

a. Group I

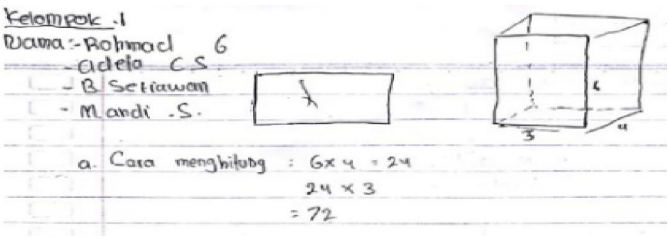

Figure 3. Group I Student Answer Results

The following interactions occur between teachers and students:

Teacher: How do you fill the unit cube into the cuboid? how to arrange a unit cube into a cuboid?

Student: yes, just put it in the available cuboid. For preparation we put all the cubes of the unit into the cuboid until there is no more empty space.

Teacher: How do you calculate the number of unit cubes in the cuboid? How is the known cuboid size relationship with the unit cube?

Student: After we put the unit cube into the cuboid to the full, we take it out again to calculate the number of unit cubes that make up the cuboid.

Teacher: Can or not without removing it you can find out the many cubes of units that make up the cuboid?

Student: Can you pack. We count the lines from the unit cube which is the length and width of our times. The results are multiplied again by the height of the pack.

Based on the results of group discussions and interviews, it can be seen that from the answers of group 1 when the group fills the unit cube on the cuboid they do not directly calculate it but they count the number of unit cubes after filling the unit cubes into the cuboid. The way they calculate the number of unit cubes contained in a cuboid is to calculate the number of unit cubes that form the length, width and height of the cuboid, namely 4, 3 and 6, then calculate the number of unit cubes that form the sides of the cuboid by multiplying the height and length. After obtaining the results, they multiply the results by the width of the cuboid, so that the results they get are 72 unit cubes that fill the cuboid. For question b, group 1 does not work but from the results a can be concluded that this group understands the relationship between length, width and height to calculate the number of unit cubes contained in the cuboid.

b. Group II

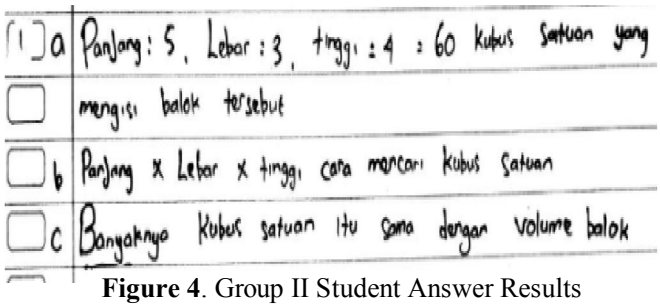

Figure 4. Group II Student Answer Results

Teacher: How do you fill the unit cube into the cuboid? how to arrange a unit cube into a cuboid?

Student: We put the unit cube into the cuboid according to the direction of the father. Then after filling in until full, we calculate the number of cube units. For the compilation of the cubes the units we put are arranged up and sideways according to the shape of the cuboid, until the cuboid becomes full.

Teacher: How do you calculate the number of unit cubes in the cuboid? How is the known cuboid size relationship with the unit cube?

Student: We calculate the row of unit cubes which form the length, width and height of the cuboid, after we get the results we multiply the pack.

From group 2 answers and interviews, it appears that when the group fills the unit cube on the cuboid they do not directly calculate it but they count the number of unit cubes after filling the unit cubes full into the cuboid. The way they calculate the number of unit cubes contained in a cuboid is to calculate the number of unit cubes that form the length, width and height of the cuboid, namely 5, 3 and 4, then multiply the length, width and height so that the results they get are 60 unit cubes fill the cuboid. From the group answers it appears that they understand that to determine how many unit cubes can be filled in the cuboid is by multiplying the length, width and height of the cuboid. The last conclusion they give is the number of unit cubes contained in the cuboid is the volume of the cuboid.

c. Group III

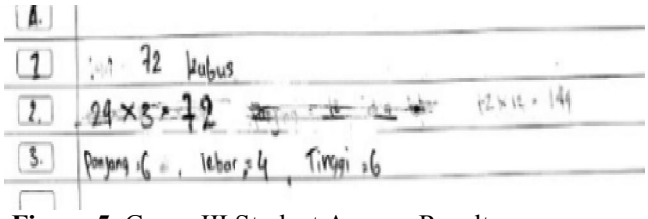

Figure 5. Group III Student Answer Results

The following interactions occur between teachers and students:

Teacher: How do you fill the unit cube into the cuboid? how to arrange a unit cube into a cuboid?

Student: We put one by one unit cube into the cuboid. How to arrange it we arrange cubes according to the size of the cuboid.

Teacher: How do you calculate the number of unit cubes in the cuboid? How is the known cuboid size relationship with the unit cube?

Student: We put the unit cube into the cuboid while calculating so that when it is fully charged, that's the result, sir. From the cuboid, to determine the length we calculated the number of unit cubes on the length, width and height of the cuboid.

From the answers of group 3 and interview, it can be seen that students fill the unit cube into the cuboid while calculating so that the group obtains the number of unit cubes that can be filled into the cuboid are 72 unit cubes. The group wrote 24 x 3 = 72 with the number of unit cubes that formed a length = 6, width = 4 and height = 6. From this group's answer it can be seen that the group calculates the number of unit cubes that form the side of the cuboid which is 24 and multiplies by 3 so produce the number of unit cubes is 72 pieces.

d. Group IV

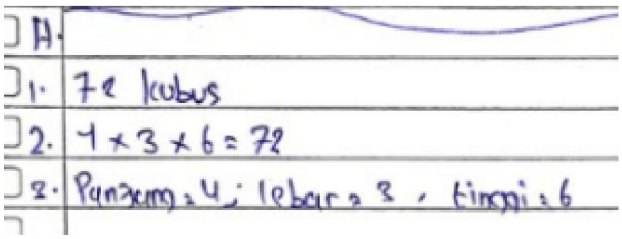

Figure 6. Group IV Student Answer Results

The following interactions occur between teachers and students:

Teacher: How do you fill the unit cube into the cuboid? how to arrange a unit cube into a cuboid?

Student: according to instructions from the father, we put the unit cube into the cuboid. We carried it from the bottom of the cuboid up to the full.

Teacher: How do you calculate the number of unit cubes in the cuboid? How is the known cuboid size relationship with the unit cube?

Student: we put the unit cube into the cuboid while calculating so that when it is fully charged, that's the result, sir. Then, to determine our size, calculate the unit cube line at length,

then the unit cube on the width and height of the cuboid, then we multiply it and the result is the same as sir.

From the answers of group 4 and interview, it can be seen that students fill the unit cube into the cuboid while calculating so that the group gets the number of unit cubes that can be filled into the cuboid is 72 units of cubes. The group calculates the number of unit cubes which form the length, width and height of the cuboid, namely 4, 3 and 6, then multiplies the length, width and height so that the results they get are 72 unit cubes that fill the cuboid. So it can be concluded that students understand the relationship of length, width and height to calculate the number of unit cubes contained in the cuboid.

In the second activity, each group is given 12 unit cubes and then arranged into a cuboid shape.

Figure 7. Group Activity Composes 12 Unit Cubes into Cuboids

From the picture above, the teacher gives support to students to count the cuboids formed from 12 unit cubes.

The following are the results of the students' work on problem II:

a. Group I

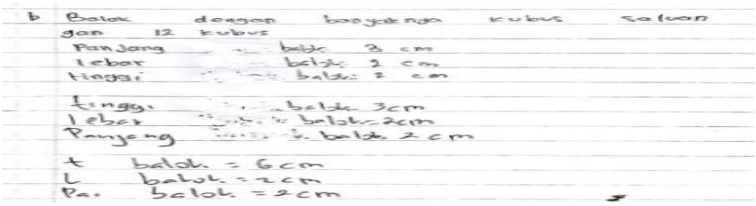

Figure 8. Results of Group 1 Student Answers

The following interactions occur between teachers and students:

Teacher: Which do you think is the length, width and height of the cuboid?
Student: Here sir (while showing the props).
Teacher: How many cubes are there on this line?
Student: On this line there are 3 packs.
Teacher: How do you know the length, width and height of the cuboid?
Student: According to what we have arranged, the length is 3, the width is 2 and the height is 2 packs.
Teacher: How do you know the volume of the cuboid?
Student: Because 12 cubes have been given to form cuboids, the volume is 12 packs.

Based on the results of group discussions and interviews, it can be seen that group 1 gets 3 cuboid shapes, namely a cuboid measuring 3 cm × 2 cm × 2 cm; 2 cm × 2 cm × 3 cm; 2 cm × 2 cm × 6 cm. Here group 1 is still wrong to determine the size of the cuboid, which is at the third size.

b. Group II

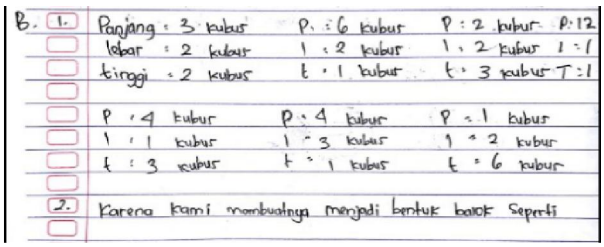

Figure 9. Results of Group 2 Student Answers

The following interactions occur between teachers and students:

Teacher: How do you form cuboids from the 12 cube units?

Student: From the 12 unit cubes we first arrange in 1 row, then 2 rows and 3 rows of packs and so on. The lines formed from these cubes that eventually form a cuboid.

Teacher: How do you determine the length, width and height of the cuboid?

Student: We calculate the many sides of the unit cube which are in the length, width and height of the cuboid.

Teacher: What results from your work can you conclude?

Student: In our opinion, sir means that the volume of the cuboid is p times l times t pack.

Teacher: Why can you conclude like that?

Student: From the results we obtained the results of the length, width and height of the cuboid were 12 packs.

Based on the results of the discussion and group 2 interviews obtained 7 cuboids measuring 3 cm × 2 cm × 2 cm; 6 cm × 2 cm × 1 cm; 2 cm × 2 cm × 3 cm; 12 cm × 1 cm × 1 cm; 4 cm × 1 cm × 3 cm; 4 cm × 3 cm × 1 cm; and 1 cm × 2 cm × 6 cm. The group is able to draw conclusions from the results of their work well.

c. Group III

Figure 10. Results of Group 3 Student Answers

The following interactions occur between teachers and students:

Teacher: How do you form cuboids from the 12 cube units?

Student: First of all we divide 12 unit cubes into 2 rows with a length of 6 cubes, 1 width and 2 pack height. Then we began to understand and we tried to change the arrangement.

Teacher: Try showing off the props which are length, width and height?

Student: This one pack (while showing on the unit cube line that forms the cuboid). As we made here, the length is 3, the width 2 which is on the side and the height is 2 which is upwards.

Teacher: What results from your work can you conclude?

Student: We are confused by the conclusion sir.

Teacher: In that case, what do you think is the relationship between length, width and height with a cuboid measuring 12?

Student: In our opinion, like the number of packs.

Teacher: Please make a conclusion between the volume of the cuboid and the multiplication of the numbers you get.

Based on the results of discussions and interviews, group 3 obtained 5 cuboids with a size of 4 cm × 3 cm × 1 cm; 3 cm × 2 cm × 2 cm; 2 cm × 2 cm × 3 cm; 2 cm × 1 cm × 6 cm; and 1 cm × 1 cm × 12 cm. This group has been able to determine the possibilities of the cuboid but has difficulty in concluding. Here the researcher provides support by asking students to connect the multiplication with the volume of the cuboid.

d. Group IV

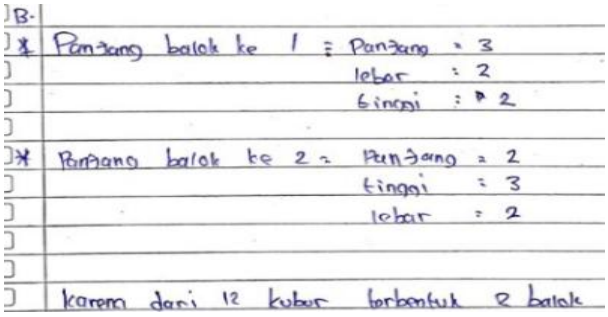

Figure 11. Results of Group IV Student Answers

The following interactions occur between teachers and students:

Teacher: How do you form cuboids from the 12 cube units?

Student: Out of the 12 unit cubes we gave, we tried to arrange 2 rows of unit cubes and we got 2 pack cuboids.

Teacher: How many cubes are there on this line? What do you think is the length, width and height of the cuboid?

Student: There are 3 packs. We see based on the side of the unit cube which is in the length, width and height of the cuboid.

Teacher: What results from your work can you conclude?

Student: In our opinion, pack means that from the 12 unit cubes we can arrange into 2 cuboids.

Based on the results of the discussion and interview group 4 obtained 2 cuboids with sizes 3 cm × 2 cm × 2 cm and 2 cm × 3 cm × 2 cm. This group was able to compile the given cubes of units into cuboids but the results of the discussion in the group only found 2 forms of cuboids. The conclusions given are in accordance with the results they get.

Each group writes the size of the cuboid obtained from the unit cube props arranged to form cuboids of various sizes described above. The process carried out by each group is to compile the cubes that have been provided into a cuboid of various sizes to explain how to obtain the size of the cuboid. Here there are 3 groups that are able to explain the results of their work well while 1 group is unable to provide an explanation.

3.4. Stage 4: Develop and Present Results

At this stage, the teacher appoints several groups to present the results of problem solving while helping students who experience difficulties. This activity is useful to know the results of students' understanding and also the results of problem solving.

Figure 12. Presentation of the answers by one group

The following interactions occur during the discussion process:

Teacher: Well, from the results of the presentation, are there any other groups who want to respond?

Student1: We, sir, from the results of group 1, the number of cubes was 72 while the results we got were 60 with a length of 4 cuboids in width 3 and a height of 6 packs.

Teacher: Because this teaching aid is in the form of plastic and the surface is elastic, the results obtained from your group are different, but the concept you are doing is right. For the next problem is there a response?

Students: The results we got at number 2 many cuboids that might have formed were 7 pack cuboids.

Teacher: So, all the factors of 12 are the length, width and height of the cuboid.

3.5. Stage 5: Analyze and Evaluate the Problem Solving Process

The teacher helps students to evaluate and reinforce the processes they have carried out, as well as their understanding and conclusions about the volume of the cuboid. that is, if the volume of the cuboid is known, it can be determined the length, width and height of the cuboid by looking for numbers which are a factor of the volume. So the volume of the cuboids is times the width of the height times. The following interactions occur between teachers and students:

Teacher: What have you learned today?

Student1: Use unit cube props and cuboids to find out the length, width and height of the pack cuboid.

Teacher: If the volume of the cuboid is known, the length, width and height of the cuboid can be determined by looking for numbers which are a factor of the volume. What is the volume of the cuboid?

Students2: The volume of the cuboids is times the width of the height.

Teacher: Good, then the lesson is finished today. Let's pray.

4. Conclusion

Based on the results and discussion that has been described in the learning design using the Problem Based Learning model can help students in determining the volume of the cuboid. Students are asked to use unit cube props and cuboids. Next, students solve the problem given by arranging the unit cubes into the cuboid that has been provided and from the 12 unit cubes given by students to form cuboids. From these activities, students can make conclusions about the volume of the cuboid.

Based on the results of this study indicate that the learning process goes well according to the HLT that the researcher designed follow the stages of Problem Based Learning and the use of Problem Based Learning can support students in understanding the volume cuboid..

References

[1] Afandi. Mahmud,dkk. 2013. *Model dan Metode Pembelajaran di Sekolah*. Semarang: Unissula Press. 27

[2] Agus Salim & Ali Forman. 2006. *Pengantar dan Berpikir Kualitatif dalam Agus Salim, Teori dan Paradigma Penelitian Sosial.* Yogyakarta: Tiara Wacana. 22-23

[3] Arens, Richard I. 2007. *Learning To Teach Sevenh Edition.* 57

[4] Charitas Indra Prahmana, Rully.2017. *Design Research: (Teori dan Implementasinya: Suatu Pengantar)*. Depok: Rajawali Pers. 13

[5] Indriani, Novi & Julie , Hongky. 2017. *Developing learning trajectory on the circumference of a cycle with realistic mathematic education*. AIP conference proceedings.

[6] Trianto.(2007). *Model-Model Pembelajaran Inovatif Berorientasi Konstruktivisme. Konsep, Landasan Teoritis-Praktis dan Implementasinya*. Jakarta: Prestasi Pustaka. 67