The effect of problem based learning model on junior high school students’ higher order thinking skills

E N Imamah1, Sunardi1, E Yudianto1, M P Sari1, N I Laily1
1Department of Mathematics Education Postgraduate, University of Jember, Indonesia
E-mail: evhireyvhi@gmail.com

Abstract. The facts indicate that students’ higher order thinking skills at second grade of SMPN 1 Jember is relatively low. They were only learning with assignments in class and did not use theory to solve their problems. Therefore, we conduct a research on mathematical learning through Problem Based Learning model to find out the effect of students’ higher order thinking skills. The method used in this study is a mixed method. The quantitative method is used to analyze student learning achievement and students’ higher order thinking skills. This experimental research have two classes which are control class and experimental class that contain 32 students each class. The result showed that Problem Based Learning model had a positive effect on higher order thinking skills. It can be seen from the percentage of higher order thingking skills of control class was 40,63% and experimental class 90,62%.

1. Introduction

Education experiences changes along with the development of communication and technology. Learning pattern should also change in order to be relevant with the challenges and opportunities occur in real life. Education is expected to be able to be implemented in daily life. The problems occur in daily life can be presented in mathematics learning in school context. Nowadays, learning models are very various and enables educators to choose one of the most suitable learning models to improve students’ thinking abilities at school. Besides that learning ability, the students should have the ability of adaptation, learning, innovation, and character. One of the learning models that can be seen its effectiveness toward the students’ thinking skill is Problem Based Learning.

Problem Based Learning is a cooperative learning model that uses real life problems as the context for the students to learn about critical thinking and problem solving skills [1–3]. PBL is a learning that gives the students exposure to practical problems as the foothold in learning or in other words, students’ learn through problems [4]. The problems given are based on an authentic real life situation which has various possible solutions to one problem [5]. REGARD to what obtained from the process of PBL, individual becomes a good problem solver by using their higher-order thinking skills [6]. PBL, in comparison to other learning models is a learning model and a complex constructivist which provides great opportunities to the development of learning autonomy [7]. PBL can help the students to develop cognitive competences [8]. From the explanation above, it can be known that PBL is a learning model that implements real life problems and is one of the cooperative learning methods that develops the students’ thinking skills so that it can be used as a learning model to see its effect on higher-order thinking skills.

Higher Order Thinking Skill (HOTS) as a skill occurs when someone links information stored in memory with new information, then delivered the combined information to reach the goals or needed
answer [9]. HOTS involves the students to link their learning and other outside elements taught to be connected with them. Thinking skills are divided into two categories: higher order thinking skills (HOTS) and lower order thinking skills (LOTS) [10]. LOTS consists of the first three aspects of bloom's taxonomy including remembering, understanding, and applying [11,12]. In HOTS, Bloom's Taxonomy that can be used are analyze, evaluate, and create [13]. Teachers can play the roles by using a variety of questions in order to demand the use of higher-order thinking in the classroom while recognizing the difficulties faced by students in solving problems related to HOTS [12]. Higher-order thinking skill is an important aspect in teaching and learning especially in higher education institutions [14]. From the above explanation it can be concluded that thinking skills are divided into two namely LOTS and HOTS. HOTS is a thinking skill that is carried out using Bloom's taxonomy which are analyze, evaluate, and create. Research conducted by Verdina shows teaching and learning that can improve Higher Order Thinking Skills are able to improve ability in problem solving and critical thinking. So that critical thinking is also included in high-level thinking. Therefore, the research conducted by Suntusia by using the Research Based Learning model can be analyzed to determine the ability to think at a high level of students [11]. Research conducted by Meke found that PBL using manipulative material has a positive effect on student performance looking at cognitive variables in understanding problems (remembering and understanding), and solving problems (analyzing and evaluating) procedural knowledge and conceptual knowledge [15]. From the research conducted previously, it shows PBL had a positive impact on students' thinking. Therefore the research conducted using the PBL model. From the above research it can be seen that PBL has an impact on students' procedural and conceptual thinking. Researcher use the PBL model to determine the impact on students' high-level thinking. This research was conducted at 1 Jember Junior High School in class VIII. The HOTS effects can be seen through PBL learning model, therefore the researcher wanted to know the effect of the Problem Based Learning tools on higher-order thinking skills on the students of SMPN 1 Jember.

2. Method

The method used in this research was mixed method research. According to [16], a mixed method is the research method that is combining qualitative and quantitative methods. This type of research is experimental research conducted in the experimental class and the control class. the experimental research method is a research method used to look for the effect of certain treatments on others under controlled conditions. The research was conducted at SMPN 1 Jember with class VIII students as the respondents in the odd semester of the 2019-2020 school year. In the experimental class and the control class each consisted of 32 students.

The research began with the tools validation, then the tools trial on a group of students until it ended in administering the test and giving a questionnaire to the experimental class that was given treatment. The population in this research amounted to 64 which were divided into 2 classes, namely the experimental class and the control class.

Data collection methods used were test and observation. The test in this research consisted of two higher-order thinking skills questions. The test was carried out to measure the students' higher-order thinking skills. The administration of students’ learning achievement test was a data collection technique regarding students’ learning achievement after the Problem Based Learning model was applied. The Observation method was used to find out the percentage of learning implementation by using problem based learning model.

The data analyzed in this research were the data of learning achievement test given to two classes. The preliminary data analysis were obtained from the last daily test scores through normality test of both classes. The data obtained were normal therefore the homogeneity test was performed of both classes. Two classes were homogeneous therefore the experimental and control classes were selected randomly. Due to the homogeneous data obtained from the homogeneity test, therefore the hypothesis test used t-test. T-test was carried out to know whether or not the treatment had an effect to the
3. Results and Discussion
The preliminary data collections were obtained from the daily test on function chapter to do the normality test. After the preliminary data were proven to be normal then the homogeneity test was carried out. If the two classes were proven to be normal and homogeneous then the treatment was given to one of classes by applying problem based learning method and the other class was taught by using the learning which has been used by the teacher. This was done to know the influence of problem based learning model implementation on the students’ higher order thinking skills. The final data were obtained from the test of both classes with 3 essay questions. Because the preliminary data were normal and homogeneous then the t-test was done to know if there was a difference between two classes.

3.1 Normality test
Data on daily test scores for function material is used as preliminary data to determine the normality of the two classes. Test for normality using IBM SPSS software version 25.

| Table 1. Normality test result from the daily test |
|-----------------------------------------------|
| Kolmogorov-Smirnov | Statistic | Df | Sig. |
|---------------------|-----------|----|-----|
| Test scores         | 0.082     | 32 | 0.200 |

The table above was the results of normality test on the data of two classes in this research. The data were obtained from the daily test of the previous material. According to [17] that Normality test showed that two groups were normally distributed if the significant value was higher than 0.05. On the table 1 showed that the significant value was 0.200 which meant that two classes were normal. Both classes are declared normal, meaning that both classes have normally distributed data.

| Table 2. Normality test result from the post test |
|--------------------------------------------------|
| Kolmogorov-Smirnov | Statistic | Df | Sig. |
|---------------------|-----------|----|-----|
| Test scores         | 0.102     | 32 | 0.200 |

The table above was the results of normality test on the data of two classes in this research. The data were obtained from post test. On the table 1 showed that the significant value was 0.200 which meant that two classes were normal. Both classes are declared normal, meaning that both classes have normally distributed data. Therefore, in order to process the next step for the post test that to see whether the values of both classes are homogeneous, it used a homogeneity test.

3.2 Homogeneity test
When two classes were said to be normal then the homogeneity test was done to know whether or not two classes had the similar ability or homogeneous. The homogeneity test used IBM SPSS version 25 software.

| Table 3. Homogeneity test result |
|---------------------------------|
| Levene Statistic | df1 | df2 | Sig. |
|------------------|-----|-----|-----|
| 1.932            | 1   | 62  | 0.170 |

The homogeneity test was used to determine whether or not two classes to be investigated were homogeneous. The results of homogeneity test of the students were obtained from the daily test scores on the previous material with the significant value of 0.170. According to [17] that if the significant value was higher than 0.05 then the data were homogeneously distributed. The results of homogeneity test that were done in two classes proved to be homogeneously distributed. Because both classes
proved to be homogeneous, it could be used for this research. One class for the experimental class and the other for the control class.

| Levene Statistic | df1 | df2 | Sig. |
|------------------|-----|-----|------|
| 1.773            | 1   | 62  | 0.188|

The results of homogeneity test of the students were obtained from the daily test scores on the previous material with the significant value of 0.188. Both classes have proven homogeneous values. Both homogeneous classes mean both classes have homogeneous variance. Because both classes proved to be homogeneous, the next step was to do the t-test to see the differences in values from both classes.

3.3 T-test
The initial data were tested by using IBM SPSS version 25, the initial data were normal and homogeneous, so that the final t-test was distributed by using the same software.

| Levene’s Test for Equality of Variances |
|----------------------------------------|
| Test Equal variances assumed           |
| F | Sig. | t  | Df | Sig.(2-tailed) |
|---|------|----|----|---------------|
|   | 1.773| .188| -9.278| 62 | .000         |
| Equal variances not assumed            |
|                                         |
|                                         |
|                                         |

Regarding the results of t-test, the students’ learning achievement in solving questions of higher order thinking skill got a significant value of 0.000. According to the statement pointed by [18], if the significant value was 0.000 then there was a difference between the experimental class and the control class.

In the test of learning achievement, 3 problems containing 3 levels of higher order thinking skill were given. The first problem was about an analysis-level question by linking the daily problems to related material. The second problem given was an evaluation-level question. Moreover, the last problem given was a creating-level question of higher-order thinking skill. In the first and second problems, the maximum score counted for each was 30 and the score given to the third problem was 40. Figure 1 showed that the numbers of students who had the minimum analytical skills were categorized into higher-order thinking skill.

![Figure 1. Comparison of students' higher thinking skills in the experimental class and the control class](image-url)
There were differences found in two classes as shown on Figure 1, the result gained by experimental class was higher than the control class. It can be seen on Figure 1 above who revealed that those having higher-order thinking skill consisted of 29 students in the experimental class, while the control class covered 13 students with higher-order thinking skill.

![Comparison of students' high-level thinking skills](chart.png)

**Figure 2.** Comparison of students' high-level thinking skills in the experimental class and the control class

The experimental class showed that the students with higher-order thinking skills covered 29 students in which they were different from 5 students with analysis level, 22 students with evaluation ability, and 2 students with creating ability. Whereas in the control class, there were 13 students who possessed higher-order thinking skills, 10 students with analysis level, 3 students with evaluation level, and none of them were at the level of creating.

### 3.4 Students' activities

In the experimental class, students work and ask question each other and the nuances of caring grow between one another's friends. The activities of students asking questions and explaining and exchanging opinions in groups are presented in the following figure 3, (taken from one group as a sample).

![Figure 3. students' activities at experimental class](activity.png)

Group discussion in the experiment class went smoothly where Student B was the focal point of brainstorming and explained to students who did not understand. In the Experiment class it was also seen that Student D and Student C were very enthusiastic in helping explain to Student A. This shows that students were able to collaborate each other.

![Figure 4. students’ activities at control class](activity_control.png)
Discussions in the control class only occur in students A and B. Students C and D do not understand the material but do not ask friends who understand. Other students simply copy their friend’s answer without understanding the answers. Overall, the group discussion that occurred in the control class only aimed to answer the problem given by ignoring whether their groupmates had understood it or not.

3.5 Students’ result
Problems given to students in the form of 3 problems in higher order thinking are as follows:

1) The picture below is the position of the stairs that are used for the needs in the shop. Which of the stairs above is safest to use? what distinguishes stairs A to C? The slope / gradient of the stairs may not exceed 0.875

![Stairs Diagram]

2) Nino's father has Rp.100,000,000.00. He wants to save part of the money after 2 years. The interest offered is 5% annually. Because there is a need at home, Nino's father's money was used in the amount of Rp. 20,000,000.00.
   a. Try to predict how much money Nino's father after 2 years? (Interest used on bank A is a single interest with the same increase every year).
   b. Draw a straight line equation according to the problem above!
3) Every hospital has a road that is passed by a wheelchair user, as shown below. Make a design or sketch of the road by paying attention to safety for road users. The slope requirements on the road must not exceed 0.15 and the height of the road must be at least 1 meter.

In the first problem, it can be solved using analysis, the second problem using a evaluation levels and the third problem using the level of creating.

Here are the answers of students who have created levels
The results of student above can be seen that students are able to solve all three problems correctly. In problem 1 students can determine the safest stairs of the three stairs. In problem 2 students can determine the initial amount of savings and be able to draw a straight line equation according to the situation. The three students were able to design a stairs with a height of 1 meter with a predetermined gradient. This student has the ability to create. students who have the ability to create in this study are 2 students in the experimental class.

3.6 Discussion
This research was conducted to determine the effect of problem-based learning models on the students' higher order thinking skills in the material of straight-line equations. The results of this research showed that the implementation of problem-based learning had a significant effect on improving the students' higher order thinking skills. This research showed, the higher order thinking skills of the students in the control class were 37.5%, while in the experimental class were 84.37%. From the results of the research, the experimental class students showed that their higher order thinking skills were higher than the control class.

These results are the same as a study conducted by Budhi. This study aims to see the effect of students' ability to solve problem after PBL learning models. Hypothesis test results using the t-test showed that p = 0.000 with t count 3.993. Based on these results it can be concluded that there are differences in critical thinking skills between students who use problem-based learning or direct instruction. By looking at the average problem based learning and direct instruction groups it was found that problem based learning was greater than direct teaching because the average problem based learning was 22.73 while direct teaching was 19.50[18].

The research which conducted by Meke found that PBL using manipulative materials had a positive effect on student performance that can bee seen on cognitive variables in understanding problems (remembering and understanding), solving problems (analyzing and evaluating), procedural knowledge and conceptual knowledge. PBL using manipulative material has given 91.93% in students...
'ability to remember, 87.09% in students' ability to understand, 84.08% in students' ability to analyze and 69.15% in students' ability to evaluate. It can be concluded that the class using the problem based learning model affected students' higher order thinking skills[1].

4. Conclusion
The result of normality test that was performed by using IBM SPSS version 25 software obtained a significant value of 0.056 and the data was considered normal. Homogeneity test obtained a significant value of 0.188, then both classes were said to be homogeneous. The data of learning achievement test was done by t-test and had a significant value of 0.000, then the data differed in the two classes.

The result showed that Problem Based Learning model had a positive effect on higher order thinking skills. It can be seen from the percentage of higher order thinking skills of control class was 37.5% and experimental class 90.62%. In the experimental class the average value is 65.22 while in control class is 23.75. In the experimental class showed that students who have high-level thinking skills are 29 students with high-level thinking skills that are different from students who have a level of analysis that is 5 students, students who have an evaluation ability of 22 students, and who have the ability to create are 2 students. Whereas in the control class that has high-level thinking skills, 13 students with an analysis level of 10 students, an evaluation level of 3 students, and no students who are at the level of creating. In this study it was different from the study conducted by Meke who found PBL had a positive effect on cognitive variables, n this study found that PBL also had an effect on higher order thinking skills.

Acknowledgment
I gratefully acknowledge the support from Geometry Research Groups, FKIP-University of Jember Indonesia of the year 2019.

References
[1] Meke K D P, Wutsqa D U, and Alfi H D 2018 The Effectiveness of Problem-based Learning Using Manipulative Materials Approach on Cognitive Ability in Mathematics Learning J. Phys. Conf. Ser. 1097 (1).
[2] Yudianto E, Sugarti T, and Trapsilasiw D 2018 The Identification of Van Hiele Level Students on the Topic of Space Analytics Geometry J. Phys. Conf. Ser. 983 (1) 012078
[3] Sunardi S, Yudianto E, Susanto K, Kurniati D, Cahyo R D and Subanji S 2019 Anxiety of Students in Visualization, Analysis, and Informal Deduction Levels to Solve Geometry Problems Int. J. Learn. Teach. Educ. Res. 18 (4) 171–185
[4] Nasution M L, Yerizon Y, and Gusmiyanti R 2018 Students’ Mathematical Problem-Solving Abilities Through the Application of Learning Models Problem Based Learning IOP Conf. Ser. Mater. Sci. Eng. 335 (1)
[5] Iqbal M, Yusrizal, and Abidin Z 2018 The development of learning instruments through the problem-based learning model to enhance students’ creativity The development of learning instruments through the problem-based learning model to enhance students’ creativity J. Phys. Conf. Ser.
[6] Ersoy E 2014 The effects of problem-based learning method in higher education on creative thinking 116 3494–3498
[7] Darma I K, Candiasa I M, Sadia I W, and Dantes N 2018 The effect of problem based learning model and authentic assessment on mathematical problem solving ability by using numeric ability as the covariable The effect of problem based learning model and authentic assessment on mathematical problem solving abil 1–9
[8] Drăghicescu L M, Petrescu A M, Cristea G C, Gorgiu L M, and Gorgiu G 2014 Application of Problem-based Learning Strategy in Science Lessons – Examples of Good Practice Procedia - Soc. Behav. Sci. 149 297–301
[9] Maulita S R, Sukarmin S, and Marzuki A 2019 The Content Validity: Two-Tier Multiple Choices
Instrument to Measure Higher-Order Thinking Skills *J. Phys. Conf. Ser.* **1155** (1)

[10] Kusuma M D, Rosidin U, Abdurrahman A, and Suyatna A 2017 The Development of Higher Order Thinking Skill (Hots) Instrument Assessment In Physics Study *IOSR J. Res. Method Educ.* **07** (01) 26–32

[11] Verdina R, Gani A, and Sulastri 2018 Improving students’ higher order thinking skills in thermochemistry concept using worksheets based on 2013 curriculum *J. Phys. Conf. Ser.* **1088**

[12] Abdullah A H, Liyana N, Abidin Z, and Ali M 2015 Analysis of Students’ Errors in Solving Higher Order Thinking Skills (HOTS) Analysis of Students’ Errors in Solving Higher Order Thinking Skills (HOTS) Problems for the Topic of Fraction

[13] Pratama G S and Retnawati H 2018 Urgency of Higher Order Thinking Skills (HOTS) Content Analysis in Mathematics Textbook *J. Phys. Conf. Ser.* **1097** (1)

[14] Ahmad M Z S, Prahmana R C, Kenedi A K, Helsa Y, Arianil Y 2018 The instruments of higher order thinking skills

[15] Muin A, Hanifah S H, and Diwidian F 2018 The effect of creative problem solving on students’ mathematical adaptive reasoning *J. Phys. Conf. Ser.* **948** (1)

[16] Sugiono 2017 Metode Penelitian Kombinasi (mix method) Bandung, Indonesia: *Alfabeta*

[17] Miatusn A and Muntazhimah M 2018 The effect of discovery learning and problem-based learning on middle school students’ self-regulated learning *J. Phys. Conf. Ser.* **948** (1)

[18] Budhi W and Suwarni S 2019 Effect of problem based learning on critical thinking ability on science *J. Phys. Conf. Ser.* **1175** (1)