Improving Higher Order Thinking Skills (HOTS) with Project Based Learning (PjBL) Model Assisted by Geogebra

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Abstract. The 21st century requires learning that provides a project-based and constructive experience so that higher order thinking skills can be increased. The objective of this study was to improve HOTS with Project Based Learning (PjBL) model assisted by Geogebra. Quasi-Experimental was used as the method, with simple random sampling as the sampling technique. Data collecting techniques used were the test method to see the improvement of HOTS. The hypothetical test used was one-way ANOVA with a significant level of 5% and N-gain was used to determine the improvement of HOTS. The results show that there is an influence from the Geogebra-assisted Project Based Learning model on higher order thinking skills. In addition, the average score of the class taught by using the Geogebra-assisted Project Based Learning (PjBL) model was higher than the non-Project-Based Learning (PjBL) class with an increase of 0.643 in the medium category. It means that learning can achieve the desired goals, the teacher must plan learning well, and the PjBL model can be made as a learning solution in the 21st century.

1. Introduction

In the era of globalization and modernization of the 21st-century, HOTS is the highest cognitive level and is the ability to connect, manipulate, and transform knowledge as an experience to think critically, logically, reflectively, metacognitively, and creatively in an effort to determine decisions and solve problems into new situations [1–3]. Curriculum changes, pedagogies, and assessments are the components of HOTS implementation [4]. The implementation of HOTS can produce many solutions [5]. The steps of action consist of logical, problem solving [6], critical thinking, reasoning, requiring an effort to think critically and creatively to resolve challenging situations in decision making [7–11], and arguing and communicating based on the higher-order thinking skills [11, 12].

The implementation of HOTS is an important aspect in learning mathematics [4], so that students can find concepts and develop their mathematical abilities in solving problems [13, 14], achievement, and can make a positive contribution to the world of education [1, 15–17]. Facts show that in solving problems, the students only focus on the final results so that the average HOTS of students is classified as low [18, 19], lack of non-routine questions [14, 20, 21], not accustomed to solve problems related to higher-order, critical, and creative thinking problems [23–25].

The success of students in managing HOTS can be determined by a learning model [25, 26]. Efforts to improve student learning outcomes are the goal of the learning model [27, 28].

The results of previous studies indicate that the PjBL model can improve higher-order thinking skills [30]. Project-Based Learning (PjBL) is a centralized, innovative, project-based learning model that has been applied in developed countries [31, 32]. PjBL learning is authentic in a constructive
investigation by giving direct experience to students through project-making activities so that the teacher is only as a facilitator[22, 33]. Projects contain complex, challenging, and demanding tasks for students to design, solve, decide, investigate, and provide opportunities for students to work independently [34]. The PjBL can have a significant influence on creative thinking skills, learning outcomes [35], and higher-order thinking skills [36]. So that the Project Based Learning (PjBL) model is appropriate to be used to improve higher-order thinking skills.

In addition to choosing the right model, the use of instructional media, such as Geogebra, is important in achieving learning objectives because the use of instructional media can build understanding and mastery of learning objects [37]. Geogebra is a mathematical software that combines geometry, algebra, and calculus [38]. Geogebra is used to help the process of teaching and learning mathematics to facilitate students in understanding the material and constructing points, vectors, line segments, cone slices, and even functions as well as able to change them dynamically. Also, Geogebra can connect variables with numbers, vectors, and points, find derivatives and integrate functions, and give commands to find extreme points or roots [39].

Based on previous research, this study has a novelty that lies in the external variables which are the assistance of Geogebra. The purpose of this research is to improve HOTS by using Project Based Learning (PjBL) assisted by Geogebra.

2. Research Method
This study uses the quasi-experimental method. The design of this research is as follows:

| Group | Pretest | Treatment | Posttest |
|-------|---------|-----------|----------|
| A     | O₁      | X₁        | O₂       |
| B     | O₁      | X₂        | O₂       |
| C     | O₁      |           | O₂       |

Figure 1 illustrates the $X₁ = \text{Project-Based Learning (PjBL)}$ model assisted by Geogebra, $X₂ = \text{Project Based Learning (PjBL)}$ model, A = Experiment Class 1, B = Experiment Class 2, C = Control Class, $O₁ = \text{Pretest understanding of HOTS}$, $O₂ = \text{Posttest understanding of HOTS}$[40].

The populations in this study were 353 students of SMP N 1 Natar. The sampling technique used was simple random sampling technique with 89 students of the eighth grade. Experimental Class 1 used the Geogebra-assisted Project-Based Learning (PjBL) model [41], Experimental 2 used the Project-Based Learning (PjBL) model, and the control class used conventional learning. This is done so that it is easier to analyze the final results and can find out the differences, the analysis can be done with the integration of general-specific patterns [42].

Data collecting techniques used was an essay written test to see the HOTS of the students. Here are the HOTS indicators:
The steps of the Project-Based Learning (PJBL) model assisted by Geogebra are:

**PjBL model assisted by Geogebra**

- The teacher explains the topics to be studied, the learning objectives, motivation, and competencies to be achieved.
- Delivering the material through the assistance of Geogebra software.
- Divide the students into small groups of 4-5 with a variety of abilities, ethnicity, race, religion, and others.
- The group makes project plans related to solving identified problems. At this stage, the teacher makes an assessment.
- The group makes a project or work by understanding the concepts or principles related to the subject matter. At this stage, the teacher monitors and evaluates.
- The teacher or school facilitates the exhibition of work produced by students. At this stage, the teacher also makes an assessment.
- Learning evaluation

**PjBL Model (Seven Stepts)**

- The formulation the expected learning outcome
- Understanding the concept of teaching material
- Skills Training
- Designing the Project Theme
- Marking the project proposal
- Executing the task of project
- Presentation of the project report

*Figure 3* The steps of the Project-Based Learning (PJBL) model assisted by Geogebra (modified [41])
Data analysis for the normality test was the Liliefors method and the homogeneity test was the Barlet method. The hypothetical test used was one-way ANOVA test with a significance level of 5%. HOTS increase data was calculated using N-gain test with the following formula:

\[
g = \frac{(D_{\text{Post}}) - (D_{\text{Pre}})}{D_{\text{max}} - (D_{\text{Pre}})} \times 100\% \quad [43]
\]

**Table 1. The N-Gain Score [44]**

| Magnitude Gain | Category |
|----------------|----------|
| \(g > 0.7\)    | High     |
| \(0.3 < g \leq 0.7\) | Medium   |
| \(g \geq 0.3\) | Low      |

### 3. Results and Discussion

The analysis of the data was done by using the normality test using the Liliefors method and homogeneity test using the Barlet method.

Researchers collected data in the form of the results of pretest and posttest, both from the experimental class and the control class. The highest score \((X_{\text{max}})\) and the lowest score \((X_{\text{min}})\) in all three classes were sought for the central tendency including averages \((\bar{X})\), and standard deviation \((S)\). Here’s a summary of the data of the pretest and posttest.

**Table 2. Data Description of Pretest-Posttest**

| Class       | Pretest | Posttest |
|-------------|---------|----------|
|             | \(x_{\text{max}}\) | \(x_{\text{min}}\) | \(\bar{X}\) | \(S\) | \(x_{\text{max}}\) | \(x_{\text{min}}\) | \(\bar{X}\) | \(S\) |
| Experimental 1 | 36,43 | 0 | 11,032 | 10,057 | 85,95 | 52,98 | 68,7 | 9,14 |
| Experimental 2 | 26,9 | 0 | 9,483 | 7,748 | 72,56 | 30,48 | 49,52 | 12,52 |
| Control     | 30,48 | 0,952 | 14,54 | 10,12 | 63,3 | 16,7 | 38,78 | 10,54 |

Based on Table 2, it is known that the results of pretest and posttest for each class are different. Based on data, it is known that the highest score of the pretest was obtained from experimental class 1 and the lowest score was obtained from experimental class 2. Whereas the average ability of the classes, the highest average score was obtained from the control class and the lowest score was obtained from experimental class 2. Based on the data, it is known that the highest score of the posttest was obtained from experimental class 1 and the lowest score was obtained from the control class. This can also be seen based on the average score of the classes. The following is a graphic description of pretest and posttest of the experimental and control class:
Figure 4 illustrates the results of the highest and the lowest score of pretest and posttest from the three classes. The data shows a significant increase in students' HOTS after the learning processes were done. Based on the results of the posttest, prerequisite tests such as the normality test using the Liliefors method and the homogeneity test using the Barlet method were conducted. Here are the tables of normality and homogeneity:

**Table 3. The Results of Normality Test**

| Class       | n  | $L_{observed}$ | $L_{critical}$ | Conclusion   |
|-------------|----|---------------|----------------|--------------|
| Experimental 1 | 30 | 0.069         | 0.161          | $H_0$ is Accepted |
| Experimental 2 | 29 | 0.1           | 0.165          | $H_0$ is Accepted |
| Control     | 30 | 0.087         | 0.156          | $H_0$ is Accepted |

**Table 4. Homogeneity Test Results**

| Class       | n  | $L_{observed}$ | $L_{critical}$ | Result   |
|-------------|----|---------------|----------------|----------|
| Experimental 1 | 30 | 0.069         | 0.161          | $H_0$ is Accepted |
| Experimental 2 | 29 | 0.1           | 0.165          | $H_0$ is Accepted |
| Control     | 30 | 0.087         | 0.156          | $H_0$ is Accepted |

Based on table 3 and table 4, it is obtained that the data were normally distributed and had homogeneous variance. So, the data hypothesis test can be performed using the one-way ANOVA of the parametric statistics. The following are the results of the one-way ANOVA test results:

**Table 5. Hypothetical Test Results**

| Source of Variances | JK     | Dk     | RK     | $F_{observed}$ | $F_{critical}$ | Result      |
|---------------------|--------|--------|--------|----------------|----------------|-------------|
| Model (A)            | 13773,49 | 2      | 6886,74| 59,03          | 3,10           | $H_0$ is Rejected |
| Error (G)            | 10033,74 | 86     | 116,67 |                |                |              |
| Total (T)            | 23807,22 | 88     |        |                |                |              |

Figure 4 The Description of Pretest and Posttest Score
Based on Table 5, the results of one-way ANOVA on HOTS test shows that there is an effect on the improvement of students’ HOTS using the Project-Based Learning (PjBL) model assisted by Geogebra. This shows that the use of the PjBL model assisted by Geogebra is appropriate to be used to increase the students’ HOTS. Based on Table 2, the average score of the students who were taught using the Project-Based Learning (PjBL) model assisted by Geogebra is 68.7 while the average score of the students who were taught using the Project-Based Learning model is 49.52. So, it can be concluded that the Project-Based Learning model assisted by Geogebra is better than the Project-Based Learning model.

This research is almost similar to the research conducted by Salam et al. and Purwanti et al., namely the application of learning models assisted by Geogebra software show a significant influence on the students’ mathematical analogies ability and mathematical concepts understanding. Based on some research that has been conducted, the instructional media used can influence the students’ learning outcomes and thinking abilities [45, 46]. In this study, the Project-Based Learning model assisted by Geogebra affects the students’ HOTS because Geogebra is able to support students in order to pay attention to the concepts of the material and to take an active part in the learning process.

Based on Table 2, the average score of the class using the Project-Based Learning model is 49.52 while the average score of the class using the conventional learning model is 38.78. Thus, the Project-Based Learning model is better than the conventional learning model.

This research is almost similar to the research conducted by Munawaroh et al. and Mardin et al., namely the use of Project-Based Learning model show the results of building four pillars of learning and the students’ problem-solving abilities [33, 47, 48]. In this model, the students are actively required to discuss with members of their groups to solve problems in the form of projects.

Based on Table 2, the average score of the class using the Project-Based Learning (PjBL) model assisted by Geogebra is 68.7 while the average score of the class using the conventional learning model is 38.78. This research is similar to the research conducted by Nuarasih, namely the use of Project-Based Learning assisted by Geogebra which shows the results of students’ understanding of problem-solving [49, 50].

After calculating the one-way ANOVA of the pretest and posttest, it is known that there is an influence of the Project-Based Learning model assisted by Geogebra toward HOTS. However, what will be investigated here is the improvement of HOTS by applying the Project-Based Learning assisted by Geogebra. Previously, the data analysis tests such as the normality test were done using the Lilliefors method and the homogeneity was done using the Barlet test. To find out the increase in HOTS, the following is a one-way ANOVA summary table of the results of N-Gain:

| Source of Variances | JK | Dk  | RK | F_{\text{observed}} | F_{\text{critical}} | Conclusion |
|---------------------|----|-----|----|---------------------|---------------------|------------|
| Model (A)           | 2,068 | 2 | 1,034 | 54.61               | 3.10               | \( H_0 \) is Rejected |
| Error (G)           | 1,628 | 86 | 0,019 |                     |                    |            |
| Total (T)           | 3,696 | 88 |    |                     |                    |            |

Table 6 illustrates the results of the one-way ANOVA test that shows the value of \( F_{\text{observed}} = 54.61 \) with \( F_{\text{critical}} = 3.10 \), meaning that there is an improvement on HOTS. The following is the table of the results of N-Gain:

| Class         | Rate N-Gain | Category |
|---------------|-------------|----------|
| Experimental 1| 0.642       | Medium   |
| Experimental 2| 0.440       | Medium   |
| Control       | 0.272       | Low      |
Based on table 7, the average value of n-gain in the experimental class 1 is 0.643 which belongs to the medium category. That result is higher compared to the experimental class 2 which is 0.440 with the medium category and the control class which is 0.272 with the low category.

This study is the same as previous research that the PjBL model can improve learning outcomes[22]. So that PjBL learning can be a learning solution in the technological era.

4. Conclusions
Based on the data analysis, it can be concluded that the PjBL model assisted by Geogebra can influence the students’ HOTS. There is an increase in HOTS of 0.643 within the medium category. Thus, the use of PjBL is more effective in the learning process and provides better HOTS improvement.

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