Problem-based and thinking talk write learning model, mathematical reasoning, and transformation geometry

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Abstract. Several studies on learning mathematics show that students’ reasoning abilities are still low. Students may be more introduced to the use of formulas and memorizing formulas without involving reasoning. This reason is what underlies researchers to conduct research using the Problem Based Learning and Think Talk Write models. This study aims to 1) determine the effectiveness of mathematics learning by using Problem-Based Learning to improve mathematical reasoning abilities, 2) determine the effectiveness of mathematics learning by using Think Talk Write learning to enhance mathematical reasoning abilities, and 3) determine the difference between Problem-Based Learning and Think Talk Write learning models to improve mathematical reasoning abilities. The research method used in this study is quasi-experimental. The design used a pretest-posttest with a randomized control group design. Data collection techniques use test instruments to measure mathematical reasoning abilities and questionnaires to measure student learning interest. The results showed that mathematics learning with Problem-Based Learning model learning is effective in terms of increasing mathematical reasoning abilities. Mathematical learning with Think Talk Write learning models are effective in terms of increasing mathematical reasoning abilities. And, there is no difference between the Problem-Based Learning and Think Talk Write model for improving mathematical reasoning abilities.

1. Introduction
One aspect that becomes the main point in learning mathematics is mathematical reasoning. This aspect is in line with the objectives of learning mathematics in schools formulated by the National Council of Teaching Mathematics (NCTM), namely: 1) problem solving, 2) reasoning and proof, 3) mathematical communication, 4) mathematical connections, and 5) mathematical representation [1]. NCTM knows these five things as mathematical power processing standards. Also, Peraturan Menteri Pendidikan Nasional No. 22 of 2006 states that two of the five goals of learning mathematics in schools is that students can use and develop their reasoning in the process of solving mathematical problems, such as finding patterns, making evidence of mathematical phenomena so that they can apply in general.

NCTM states that reasoning is an activity that involves finding patterns, making guesses, evaluating guesses, and constructing and compiling valid proofs (mathematical arguments) [2]. Nasution added that through reasoning would help students to develop their abilities from those who only knew the basic forms in mathematics to a higher or complex level [3]. Thus, it is clearly seen that reasoning is one of the basic abilities needed in learning mathematics. Almost all levels of mathematics learning require reasoning [4].
MONE states that material in mathematics has a close relationship with mathematical reasoning. Mathematical material/concepts can be understood through reason, and conversely, reason can be trained and developed through mathematics. Therefore mathematics and reason are two things that cannot be separated because students can learn mathematics well by using reasoning [5]. Through exercises of reasoning development, students can see the problem and the adequacy of information to conclude [6].

The importance of reasoning ability in learning mathematics is not in line with the conditions of students when learning mathematics. Based on the observations of researchers, the fact that the reasoning ability of class XI students in SMA Negeri 2 Blora is still classified as moderate and even tends to low. After the researchers made preliminary observations, problems were found, including 1) the ability to present mathematical statements verbally, in writing, pictures, and diagrams (12.5%); 2) ability to submit allegations (7.5%); 3) ability to do mathematical manipulation (25%); 4) ability to provide reasons/evidence for the correctness of the solution (15%); 5) ability to conclude from statements (18%); 6) the ability to check the validity of an argument, find the nature or pattern of a mathematical phenomenon to make generalizations (22%). The problems are also seen in students when they begin working on example problems or practice questions. Most students have difficulty when having to work on questions that are not the same shape as the questions that have been exemplified by the teacher. Students are not able to solve such problems, even though the questions are similar to the example problems but require a little mathematical manipulation. Mathematical manipulation is one indicator of reasoning ability, according to Peraturan Departemen Pendidikan Nasional No. 506/C/Kep/PP/2005 [7]. Also, when students are given non-routine problems, students are confused to solve because solving such problems is not just applying a mathematical concept, but connecting two or more mathematical ideas to build results.

Several lessons have the potential to be able to improve the ability of mathematical reasoning, namely learning with the Problem-Based Learning (PBL) model and Think Talk Write [8]. Increased mathematical reasoning abilities of students who get learning with PBL approaches better [9]. PBL models are learning methods that pay attention to understanding. Students explore, assess, interpret, and synthesize information in a meaningful way. PBL is learning, which is delivered by presenting a problem, asking questions, facilitating investigation, and opening dialogue [10]. Students will work in groups to solve real and complex problems that will develop problem-solving skill, reasoning, communication, and self-evaluation skills through PBL [11]. Therefore, PBL is a good alternative teaching method to improve the academic achievement of students [12] because when teaching with PBL, students are guided to find their answer by following the steps of the PBL model [13]. One of the advantages of PBL is that it can generate students’ ideas and encourage students to argue and debate on a certain problem under discussion [14]. In contrast to conventional learning, which makes a real problem as a concept application, PBL makes a real problem as a trigger for the learning process of students before they know the formal concept. Students critically identify relevant information and strategies and conduct investigations to resolve the problem. By solving these problems, students gain or build certain knowledge and, at the same time, develop critical thinking skills and problem-solving skills [15][16][17].

Furthermore, Kurniawati explained that the PBL model with ethnomatemathics nuances could improve mathematical reasoning ability in the students of grade XI MIPA [18]. It indicates that PBL learning is believed to be able to improve the quality of learning for the achievement of targeted learning objectives. However, based on observations made by researchers shows that the learning process carried out in the classroom tends to use still conventional learning that is using lecture and teacher-centered methods even though the curriculum has been applied refers to the 2013 curriculum. Other findings also indicate that teachers do not use RPP as a reference for implementing learning in the classroom, so learning created tends to be monotonous and centered on the teacher.

In addition to the PBL model, to improve reasoning ability, one can use the TTW model. The TTW is a cooperative learning model comprises of a stage of think, talk, and write. This model constructs thought, reflection, and organize ideas. Subsequently, students should write based on their ideas. The
think-talk-write includes 3 phases consist of 1) Students learn the material (thinking), 2) Students discuss the results of learning material (talk), 3) Students write the ideas obtained from the talking phase (write) [19]. By using TTW, the students can write and develop their ideas more easily, so the students can write the descriptive text quickly and not require a lot of time. This model also makes the students more active, creative, and interested in the learning process. So, the use of TTW is effective in improving the students’ scores in writing descriptive text [20][21]. The TTW model provides predictions that problem-based learning accompanied by the TTW model will play the right role in developing logical, critical, creative thinking abilities and disposition of high school students [8]. TTW model is one of the learning models of active learning and cooperative learning. Fitriyana has researched this learning model, the results of the study indicate that there is a significant influence on the TTW strategy on understanding students’ mathematical concepts [22]. TTW model provides better learning achievement than TPS and conventional models of mathematical reasoning ability [1].

In Wahyuni’s research, by comparing learning outcomes using the PBL and TTW models, it was concluded that there were significant differences in student learning outcomes using the PBL model and the TTW model. The result shows that the PBL and TTW models can improve student learning outcomes as measured by the achievement of learning outcomes [23].

Based on the explanation above, the objectives to be achieved from this research are to find out: 1) The effectiveness of mathematics learning by using the Problem-Based Learning model to improve mathematical reasoning abilities. 2) Knowing the effectiveness of mathematics learning by using Think Talk Write learning models for improving mathematical reasoning abilities. 3) Knowing the difference between the Problem-Based Learning model and the Think Talk Write learning model to enhance mathematical reasoning abilities.

2. Methods
The research method used in this study is a quasi-experimental method with a pretest-posttest with a randomized control group design. The selection of samples on this variable is made randomly based on class rather than based on individual students so as not to disturb the learning activities that are taking place at school. The subjects to be studied were taken two classes of research samples, namely class XI IPS 4 and XI IPS 5. From each class, they would then be selected to be the experimental class 1 and the experimental class 2. The process of selecting samples was done by random sampling. The experimental class 1 was treated with the PBL learning model, and experimental class 2 was given the TTW learning model.

The research design used in this study was a pretest-posttest with a randomized control group design. The independent variable is a learning model, and the dependent variable is the ability of mathematical reasoning. The data collection used the mathematical reasoning ability test instrument and student learning interest questionnaire, as well as documentation.

Pretest reasoning abilities are given by students before treatment, to determine the students’ initial reasoning abilities before learning new material. Students are also given a questionnaire of student interest in learning to see improvement after learning is done later. At the end of the study, students will be given a post-test on their reasoning ability and student interest in the questionnaire. The data analysis is used as a t-test and correlation with the help of SPSS 16 and Ms. Excel. The t-test is used to test differences in mathematical reasoning abilities between students taught by using PBL learning models and TTW learning models. The t-test is also used to determine the average value of reasoning abilities between students taught by using PBL learning models and TTW learning models. At the same time, the correlation is used to test the relationship between student learning interest and reasoning ability. The prerequisite tests are normality and homogeneity test of mathematical reasoning ability scores and student learning interests should be check before analyzing.

3. Results and discussion
Based on the data description of mathematical reasoning ability scores taught using PBL learning models and TTW learning models on the transformation material can be seen in the following table 1.
Table 1. Average, standard deviation, maximum and minimum score of mathematical reasoning ability before and after treatment in PBL class and TTW class.

| Description                      | PBL class | TTW class |
|----------------------------------|-----------|-----------|
|                                 | Pretest   | Posttest  | Pretest | Posttest |
| Average                          | 8.222     | 20.417    | 8.528   | 20.278   |
| Standard deviation               | 2.958     | 2.430     | 2.667   | 2.410    |
| Maximum score possible           | 24        | 24        | 24      | 24       |
| Maximum score                    | 13        | 24        | 13      | 24       |
| Minimum possible score           | 0         | 0         | 0       | 0        |
| Minimum score                    | 3         | 16        | 4       | 16       |

Based on the data in table 1 above, information is obtained that the average score of mathematical reasoning ability in both classes has reached the KKM mathematical reasoning ability that is 18 after learning is applied to both classes. Furthermore, the table above shows that an increase in students’ mathematical reasoning abilities both in the PBL class and in the TTW class after learning is applied. In both PBL and TTW classes, the average score increased by 12.195 and 11.75, respectively. The data shows that the increase in the average score in the PBL class is greater than in the TTW class, although the difference in the increase in the PBL class and the TTW class is not too significantly different. However, the final condition of the average score in the PBL class is greater than the average score of the TTW class. Also, the post-test pretest data is also described based on the achievement of student scores on each indicator of mathematical reasoning ability. The results of the description of the pretest and post-test data based on each indicator of mathematical reasoning ability can be seen in the following table 2.

Table 2. Average indicator of mathematical reasoning ability in PBL class and TTW class.

| Mathematical Reasoning Capability Indicator | Average Maximum Score on Each Indicator | Average PBL Class | Average TTW Class |
|--------------------------------------------|----------------------------------------|-------------------|-------------------|
| Present mathematical statements verbally, in writing, drawings, and diagrams | 4 | 1.333 | 3.417 | 1.306 | 3.306 |
| Filing a hunch                             | 4 | 1.250 | 3.333 | 1.389 | 3.278 |
| Doing mathematical manipulation            | 4 | 1.306 | 3.583 | 1.528 | 3.472 |
| Provide reasons / evidence for the correctness of the solution | 4 | 1.333 | 3.306 | 1.389 | 3.333 |
| Draw conclusions from statements           | 4 | 1.556 | 3.389 | 1.528 | 3.500 |
| Find patterns / properties of mathematical symptoms to make generalizations | 4 | 1.444 | 3.389 | 1.389 | 3.389 |

Based on table 2 above, it can be seen that the initial abilities of students in the two classes are not significantly different. Furthermore, both in the PBL class and the TTW class each increased for each aspect of mathematical reasoning ability. The aspect of doing mathematical manipulation is the aspect that has the greatest increase in PBL class that is 2.277 while the TTW class has the greatest increase in aspects of presenting mathematical statements verbally, in writing, pictures, and diagrams and aspects of finding patterns/traits of mathematical symptoms to make generalizations that is, both are two and
aspects of concluding statements are aspects that have the lowest increase among the six aspects of mathematical reasoning ability in the PBL class.

Data on the results of students’ interest in learning described in this study consisted of two types of data, namely the pretest result data and the post-test result data. The description of the results of tests of student interest in PBL and TTW classes is presented in table 3 below.

| Description                  | PBL class |                | Kelas TTW |                |
|------------------------------|-----------|----------------|-----------|----------------|
|                              | Pretest   | Posttest       | Pretest   | Posttest       |
| Average                      | 93.833    | 92.722         | 93.889    | 94.222         |
| Standard deviation           | 7.762     | 10.479         | 7.829     | 8.462          |
| Maximum score possible       | 125       | 125            | 125       | 125            |
| Maximum score                | 108       | 113            | 113       | 114            |
| Minimum possible score       | 0         | 0              | 0         | 0              |
| Minimum score                | 80        | 68             | 85        | 78             |

Based on the data in table 3 above, information is obtained that there is a decrease in student interest in learning in PBL classes and an increase in student interest in learning in TTW classes after learning is applied. In the PBL class the average score decreased by 1.111 while in the TTW class the score increased by 0.333.

The pretest and post-test results were then converted into a qualitative form in five categories. The five categories are very high, high, medium, low, and very low. The results of student pretest and post-test data conversion in the PBL and TTW classes are presented in table 4 below.

| Score          | Criteria  | PBL class |        |        | Kelas TTW |        |        |
|----------------|-----------|-----------|--------|--------|-----------|--------|--------|
|                |           | Pretest   | Posttest|        | Pretest   | Posttest|        |
| 80 ≤ x < 87    | Very low  | 8         | 22     | 9      | 25        | 8      | 22     |
| 87 ≤ x < 94    | Low       | 14        | 39     | 8      | 22        | 14     | 39     | 9      | 25     |
| 94 ≤ x < 101   | Is        | 7         | 19     | 11     | 31        | 6      | 17     | 11     | 31     |
| 101 ≤ x < 108  | High      | 5         | 14     | 8      | 22        | 6      | 17     | 6      | 17     |
| 108 ≤ x < 115  | Very high | 2         | 6      | 0      | 0         | 2      | 5      | 2      | 5      |

Based on table 4 above shows an increase in student learning interest in PBL and TTW classes after applying PBL learning and TTW learning. Based on the above table, information is obtained that 19 students have increased student interest in learning, and there is one student who has a decreased interest in learning scores.

Based on the data analysis prerequisite testing, data that have normality, homogeneity, and average difference test have been fulfilled. This study aims to determine the effectiveness of PBL and TTW learning models on mathematical reasoning abilities. Based on the results of data analysis that has been carried out, it can be stated the following points.

3.1. Test the effectiveness of PBL learning
To find out the effectiveness of PBL learning, it must meet the effectiveness criteria outlined as follows:
3.1.1. Learning completeness (one-sample t-test). To find out the learning completeness used a one-sample t-test. The results of the learning effectiveness test on each variable can be seen in the following table 5. Based on the calculation results obtained t-count on each variable that is greater than t-table that is t0.05; 35 = 1.689 so that H0 is rejected. Therefore, it can be concluded that the average mathematical reasoning ability taught using PBL learning is more than 18.

Table 5. T-Test results for one sample learning in PBL class.

| Variable       | t-count | p-value |
|----------------|---------|---------|
| Reasoning Ability | 5.968   | 1.689   |

3.1.2. N-Gain test. Based on calculations obtained N-gain test results, as shown in table 6. The experimental class n-gain calculation results received an average pretest of 8.22 and an average post-test of 20.42. So that an n-gain of 0.79 is obtained. This result means that the PBL class has increased learning outcomes with a high category because g ≥ 0.7.

Table 6. N-Gain test results.

| Class         | PBL Class |
|---------------|-----------|
| Spretest      | 8.22      |
| Spost-test    | 20.42     |
| N-Gain        | 0.79      |
| Information   | High      |

3.1.3. Correlation test between interest and reasoning ability. Based on the criteria of student interest in the learning questionnaire, it can be concluded that the intervals of students’ interest in learning questionnaires are as follows in table 7. It is calculated that the highest percentage is student interest in learning with high criteria of 83.2%. This result means that students’ interest in learning mathematics is good by using the PBL learning model. Based on the calculation of the Spearman Rank correlation, the contribution of the influence of interest in learning to the reasoning ability is 8.24%, while the rest can be influenced by other factors such as IQ, talent, environment, attention from parents, learning methods, and so on.

Table 7. Student learning interest questionnaire.

| Interval | Lower limit | Upper limit | The midpoint | Frequency | Cumulative Frequency |
|----------|-------------|-------------|--------------|-----------|----------------------|
| 80-86    | 79.5        | 86.5        | 83           | 9         | 9                    |
| 87 - 93  | 86.5        | 93.5        | 90           | 8         | 17                   |
| 94-100   | 93.5        | 100.5       | 97           | 11        | 28                   |
| 101 - 107| 100.5       | 107.5       | 104          | 8         | 36                   |
| 108 - 114| 107.5       | 114.5       | 111          | 0         | 36                   |

3.2. Test the effectiveness of TTW learning

To find out the effectiveness of PBL learning, it must meet the effectiveness criteria outlined as follows:

3.2.1. Mastery learning (one-sample t-test). To find out the completeness of learning, using a one-sample t-test. The results of the effectiveness of learning tests on each variable can be seen in the following table 8. T-count on the mathematical reasoning ability variable is 5.667 greater than t-table, namely t (0.05; 35) = 1.689, so H0 is rejected. Therefore, it can be concluded that the average mathematical reasoning ability taught using TTW learning is more than 18.
Table 8. T-Test results for one sample learning in TTW class.

| Variable        | t-count | p-value |
|-----------------|---------|---------|
| Reasoning Ability | 5.667   | 1.689   |

3.2.2. N-Gain test. Based on calculations, N-gain test results are obtained, as shown in table 9 as follows. The results of the analysis of the control class n-gain received an average pretest of 8.53 and an average post-test of 20.28. So that an n-gain of 0.77 is obtained. This means that the TTW class also experienced an increase in learning outcomes, but the increase was in the moderate category because 0.7 > g ≥ 0.3.

Table 9. N-Gain test results.

| Class      | TTW class |
|------------|-----------|
| Spretest   | 8.53      |
| Spost-test | 20.28     |
| N-Gain     | 0.63      |

3.2.3. Correlation test between interest and reasoning ability. Based on the criteria of student interest in the learning questionnaire, it can be concluded that the intervals of students’ interest in learning questionnaires are as follows in table 10. Based on the percentage of the various criteria above, it is calculated that the highest percentage is student interest in learning with high criteria of 78.85%. It means that students’ interest in learning mathematics is good by using the TTW learning model. Based on the calculation of the Spearman Rank correlation, the contribution of the influence of interest in learning to the reasoning ability is 5.62%, while the rest can be influenced by other factors such as IQ, talent, environment, attention from parents, learning methods and so on.

Table 10. Student learning interest questionnaire.

| Interval | Lower limit | Upper limit | The midpoint | Frequency | Cumulative Frequency |
|----------|-------------|-------------|--------------|-----------|----------------------|
| 80-86    | 79.5        | 86.5        | 83           | 8         | 8                    |
| 87-93    | 86.5        | 93.5        | 90           | 9         | 17                   |
| 94-100   | 93.5        | 100.5       | 97           | 11        | 28                   |
| 101-107  | 100.5       | 107.5       | 104          | 6         | 34                   |
| 108-114  | 107.5       | 114.5       | 111          | 2         | 36                   |

3.3 The Difference between PBL and TTW Learning Models to Increase Mathematical Reasoning Ability and Student Learning Interest

After the normality and homogeneity tests for the post-test data are fulfilled, the average difference test using a sample t-test can be performed. The results of the average difference test at the post-test can be seen in the following table 11. the value of Sig. Greater than 0.05, so H0 is rejected. Therefore, it can be concluded that there are differences in the average mathematical reasoning ability and student interest in learning after the treatment is applied.

Table 11. Posttest data average difference test results.

| Data            | Sig.   | Information |
|-----------------|--------|-------------|
| Post-test Reasoning Ability | 0.965  | H0 rejected |
| Possitest Interest | 0.386  | H0 rejected |
Based on the description above, it can be seen that the criteria for effectiveness in learning refer to learning completeness, increased mathematical reasoning skills, and the positive influence of learning interest on mathematical reasoning abilities, as stated by Guskey [24]. PBL is learning that is centered on complex problems and students work in groups to identify what they need to learn [25]. Students will work in groups to solve real and complex problems that will develop problem-solving skills, reasoning, communication, and self-evaluation skills through PBL [11]. Therefore, PBL is an excellent alternative teaching method to improve the academic achievement of students [12]. There are 5 phases in PBL, namely: (1) the phase of providing orientation about problems to students, (2) the phase of organizing students to research, (3) the phase of helping independent and group investigations, (4) the phase of developing and presenting artifacts and exhibits, and (5) the phase of analyzing and evaluating the process of overcoming the problem [26]. Based on table 5, it is obtained that t-count is greater than t-table, namely $t_{0.05;35} = 1.689$ so that $H_0$ is rejected. Therefore, it can be concluded that the average mathematical reasoning ability taught using PBL learning is more than 18. That means that the post-test average of students’ mathematical reasoning abilities exceeds the minimum limit of the minimum standard criteria for mathematics applied to mathematics. Based on table 6, the results of the PBL class n-gain calculation obtained an average pretest of 8.22 and an average post-test of 20.42. So that the n-gain is 0.79. It means that the PBL class experienced an increase in learning outcomes with a high category because $g \geq 0.7$. Through data analysis using the N-Gain test, it shows that the PBL class has increased learning outcomes in a high category. Based on the percentage of the student learning interest questionnaire, It is calculated that the highest percentage is students’ interest in learning with high criteria of 83.2%. This means that students’ interest in learning mathematics is good by using the PBL learning model. The results of this study are in line with research conducted by Isgiandini, which states that the PBL learning model is better at improving students’ reasoning abilities compared to classes that do not use the PBL learning model [9][27].

The TTW model is learning that starts with thinking through reading material (listening, criticizing, and alternative solutions), the reading results are communicated with presentations, discussions, and then making a report on the presentation results [28]. Based on table 8, information is obtained that the t-count in the mathematical reasoning ability variable of 5.667 is greater than the t-table, namely $t_{0.05.35} = 1.689$, so $H_0$ is rejected. Therefore, it can be concluded that the average mathematical reasoning ability taught using TTW learning is more than 18. That means that the post-test average of students’ mathematical reasoning abilities exceeds the minimum limit of the minimum standard of KKM applied to mathematics subjects. Based on table 9, the n-gain for the TTW class obtained an average pretest of 8.53 and an average post-test of 20.28. So that the n-gain is 0.77. It means that the TTW class also experienced an increase in learning outcomes, but the increase was in the moderate category because $0.7 > g \geq 0.3$. Through data analysis using the N-Gain test, it shows that the TTW class experienced an increase in learning outcomes in the moderate category. Based on the percentage of the student learning interest questionnaire, it is calculated that the highest percentage is student interest in learning with high criteria of 78.85%. It means that students’ interest in learning mathematics is good by using the TTW learning model. The results of this study are in line with research conducted by Kusuma, which states that the TTW model provides better learning achievement than TPS and conventional models of mathematical reasoning ability [1].

4. Conclusion
There are three conclusions of this research. First, the PBL model is effective in enhancing mathematical reasoning ability. Second, the TTW model is effective in enhancing mathematical reasoning ability. Third, there is no difference between the PBL and TTW to improve mathematical reasoning ability. Considering this research is still very simple, what is obtained from the results of this study is not the final result. All limitations in this study can be used as a reference for further research namely, the preparation of learning plans need to be considered carefully, especially in the allocation of time so that every learning process that has been planned can run well and organizing students in the classroom need to be considered so that students are active in participating in learning that goes on.
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