The analysis of learning materials implementation based on research-based learning to improve the elementary school student’s creative thinking skills in solving “polamatika” problems

S I Wahyuni¹,², Dafik³, and M I Farisi²

¹ SDN Tamanan 1, Bondowoso, Indonesia
² Universitas Terbuka, Jember, Indonesia
³ Department of Mathematics Education, University of Jember, Indonesia

Email: ikewahyun31@gmail.com

Abstract. The student's creative thinking skills are very important, but in fact, it has not met an expectation. In this study, researchers tried to apply learning materials based on research-based learning to improve their creative thinking skills. This research is using a mixed method, namely a combination of quantitative and qualitative methods. Quantitative method will be used to analyze the type of interval data of student learning outcomes, while the qualitative method will be used to analyze an ordinal data of creative thinking skills. The research respondents consist of two classes, namely a control class as many as 31 students and an experimental class as many as 30 students. The score of the independent sample t-test from post-test shows that between the control class and the experimental class has a significant difference with the sig (2-tailed) value is 0.000 (p = <0.05). It can be concluded that the implementation of learning materials based on research-based learning can improve the elementary school students creative thinking skills in solving “polamatika” problems.

1. Introduction
Students in the 21st century are required to have the life skills to be able to compete in a challenging global life. To be successful in today's era, students need "21st century skills" as ideas are expressed by many business leaders, politicians, and educators [10]. These skills among other critical thinking, creative, collaboration and communication skills. To be successful and competitive in the global community, students must become experts and have skills as critical thinkers, creators, communicators, and collaborators. This competency is very important to be taught to students in all learning either in thematic content or subjects. Among the skills that must be possessed by 21st-century students is creativity. Creativity is related to the ability of both cognitive and psychomotor to generate new ideas or ways that are different from before. In general, creativity will arise if humans are faced with challenging problems.

The teacher's role is very important to grow up students' creative thinking in learning mathematics. The Torrance Test of Creative Thinking (TTCT) uses three main components in assessing creativity as fluency, flexibility, and novelty [13]. Fluency is demonstrated by the ability of students to solve many problems with appropriate solutions, flexibility refers to the ability of students to submit or build
problems with different solutions, novelty refers to the ability of students to develop new or different problems from others.

Children's academic performance can be improved through a learning that can hone students' creative thinking [15]. This will give opportunities to children who more creative to help their friends who are less creative in being able to compensate or fix weaknesses. In the aspect of solving mathematical problems required creative thinking in making (formulating), interpreting and solving models or planning problem-solving [13].

Furthermore, to measure aspects of students' creative thinking skills in solving polamatika problems, researchers describe the indicators of creative thinking skills as in the table 1 bellow.

| No. | Aspects   | Indicators                                                                 |
|-----|-----------|-----------------------------------------------------------------------------|
| 1   | Fluency   | a. Continuing image patterns correctly and smoothly                          |
|     |           | b. Colouring images patterns correctly and smoothly                           |
|     |           | c. Determine the number of red and white squares in each image               |
| 2   | Flexibility | a. Explain how to count the number of squares in the next pattern          |
|     |           | b. Determine the n-th pattern formula                                       |
|     |           | c. Prove the n-th pattern formula                                           |
| 3   | Novelty   | a. Create a new pattern                                                    |
|     |           | b. Determine the n-th formula of the pattern                                |

Apart from indicators of creative thinking, it is also important to consider the level of students' creative thinking processes. We know that not all students can comply all indicators of creative thinking, sometimes students can only meet one indicator, two indicators or even students can meet three indicators. Therefore, students' creative thinking skills levels needs to be developed to map these creative thinking skills. The level of creative thinking skills in mathematics can be developed into 5 levels, among others level 0 (not creative), level 1 (less creative), level 2 (fairly creative), level 3 (creative) and level 4 (very creative) [13]. The characteristics of each level can be seen in the table 2 bellow.

| Level            | Characteristics                                                    |
|------------------|---------------------------------------------------------------------|
| Level 4          | Students can show fluency, flexibility, and novelty in solving problems. |
| (Very Creative)  |                                                                     |
| Level 3          | Students can show fluency and novelty or fluency and flexibility in solving problems. |
| (Creative)       |                                                                     |
| Level 2          | Students can show novelty or flexibility in solving problems.       |
| (Fairly creative)|                                                                     |
| Level 1          | Students can only show fluency in solving problems.                 |
| (Less creative)  |                                                                     |
| Level 0          | Students can’t show all three aspects of creative thinking.         |
| (Not Creative)   |                                                                     |

One of the mathematical content that needs creative thinking skills is to solve the polamatika problems. In this content, students are needed to be able to think creatively in determining image patterns that accordance with the previous order. Furthermore, students are also expected to have creative thinking skills to determine patterns in the n-th order without drawing the patterns and also think creatively in making new patterns which are different from previous patterns.

To improve students' creative thinking skills, innovative efforts from teachers are needed in applying learning materials, especially in mathematics in solving polamatika problems. The implementation of learning materials that can be improving creative thinking skills is following the...
characteristics of Research-Based Learning. Research-Based Learning (RBL) is one of the learning methods that involve students directly in understanding the material (student-centered) by integrating the research as a process in building their knowledge [19]. The Research-Based Learning (RBL) model is one of the new learning models that allow students to learn and build knowledge from research steps such as having to search for information, formulate hypotheses, collect data, analyze, make conclusions and prepare reports [11]. According to Lockwood [8] and Dafik [18], RBL is a learning method that uses authentic learning, contextual learning, problem-solving, cooperative learning, hands-on & minds-on learning, and inquiry discovery approach. Research-based learning is based on a constructivist philosophy. For decades it has been recognized the usefulness of the RBL, but has not been widely adopted as a method of teaching.

While Blackmore & Fraser [14] said that the academic achievement can be improved through Research-Based Learning, namely by developing learning that guides students to be able to build their own knowledge structures. This is a very important ability in 21st century education. RBL can help students to build strong and practical intellectual relationships between research boundaries and student learning itself. RBL is learning that actively develops student skills in conducting research and allows students to practice it so that at the peak of program activities students are expected to be able to carry out autonomous research with teacher supervision [12]. Students can explain the benefits of the research they are doing and describe the skills they have acquired.

Based on the expert’s explanation, it can be concluded that RBL is a learning model with a constructivism approach that creates meaningful learning through research to build student knowledge. Through RBL, the teacher facilitates students to find solutions to their problems themselves and try to find alternative solutions from various perspectives.

Dafik [16] develops the stage of the RBL implementation as in the figure 1 bellow.

![Figure 1](image)

**Figure 1.** The stages of RBL implementation.

The implementation of research-based learning in this research is the development of research-based learning steps as explained previously which are arranged into indicators and sub-indicators of research-based learning activities as shown in the table 3.
Table 3. Indicators and sub-indicators of RBL activities.

| No | Indicators                      | Sub-Indicators                  |
|----|--------------------------------|---------------------------------|
| 1  | Problem Orientation            | a. Understanding the topic      |
|    |                                | b. Literature review            |
| 2  | Implementation of research     | a. Planning research            |
|    |                                | b. Research implementation      |
|    |                                | c. Answering question           |
| 3  | Data Analysis and Generalization| a. Data analysis                |
|    |                                | b. Data interpretation          |
|    |                                | c. Drawing conclusion           |
| 4  | Reporting of the RBL project   | a. Writing report               |
|    |                                | b. Presentation of results      |

The purpose of this research is to show the enhancement of creative thinking skills of elementary school students in solving polamatika problems after implementing learning materials based-on Research-Based Learning, (2) to show student activities when learning materials based-on Research-Based Learning is implemented in the classroom and (3) to show a portrait phase of students’ creative thinking skills in solving polamatika problems through the implementation of learning materials based-on Research-Based Learning.

2. Methods
The research design used a pre-test post-test control group design, which used two classes consisting of a control class and an experimental class [1]. Class selection was done by purposive random sampling and examined using pre-test and post-test using the following design.

Table 4. Design of the implementation of RBL model.

| Class   | Pre-test | Treatment | Post-test |
|---------|----------|-----------|-----------|
| Experiment | O₁      | X        | O₂        |
| Control  | O₃       | -        | O₄        |

This research was conducted to compare conventional learning with RBL model learning. This research used a mixed-method (triangulation). Mixed methods research is a research approach that combines or associates qualitative forms and quantitative forms. This approach involves philosophical assumptions, the application of qualitative and quantitative approaches, and the mixing of the two approaches in one study. The mixed method involves combining or integrating research with qualitative and quantitative data in research [2]. Quantitative methods are used to analyze student learning outcomes in solving polamatika problems after being the subject of RBL models. Qualitative methods are used to analyze data from the results of interviews conducted on students to find out the portrait phase of students' creative thinking skills in solving polamatika problems. The independent variable of this research is the RBL learning model. While the dependent variable is students' creative thinking skills. At the end of the session, interviews were done with the experimental class to find out the portrait phase of students' creative thinking skills in solving polamatika problems by the implementation of learning materials based on RBL.

The model of triangulation mixed methods in this research can be seen in Figure 2 below.
In the quantitative stage carried out by the pretest-posttest control group experimental method. The implementation process is by giving a pretest to all students in the control class and the experimental class. Then the learning process is done, in the experimental class carried out using learning materials based on Research-Based Learning, while in the control class carried out using learning materials that commonly used by the teacher. At the end of the activity, a posttest was conducted on both the experimental and control classes to measure students' understanding of the subject matter has been studied together. Analysis of pretest, the learning process, and the posttest becomes the basis for measuring the improvement of students' creative thinking skills in solving “Polamatika” problems.
on three indicators: fluency, flexibility, and novelty. Then, the researcher determines the level of students’ creative thinking skills based on obedience to these indicators. The results of this analysis also serve as the basis for selecting samples for qualitative research.

2.1. Population and Sample
The population of this research was all students of fourth grade SDN Tamanan 1. The sampling technique used was purposive sampling, that is one of the non-random sampling techniques in which the researcher determines the sampling by setting specific characteristics that are in accordance with the research subject matter following the subject matter in fourth-grade Elementary School. The class used is 4A as a control class with 31 students consisting of 15 males and 16 females, and 4B as an experimental class with 30 students consisting of 14 males and 16 females. The research was carried out at SDN Tamanan 1 Bondowoso because there is openness and good response in efforts to renew constructive learning activities and the learning approach applied can improve students' creative thinking skills.

2.2. Instrument
The instruments used in this research were tests, observations, and interviews. Test instruments are pre-test and post-test of essay types. The test instrument to measure creative thinking skills was analyzed using a Likert scale which includes four categories, namely very good (4), good (3), fair (2) and poor (1), as well as observation instruments to measure student’s activities, use a Likert scale that includes four categories, namely very good (4), good (3), fair (2) and poor (1). Furthermore, student’s activities were categorized into five categories, namely very active, active, hesitate, inactive, very inactive. The last is an interview to get a portrait phases of students’ creative thinking skills.

2.3. Task
In this research students in the control class and the experimental class were given essay questions about polamatika problems. Inferential statistics used an independent sample t-test to know the difference between the experimental class and the control class by comparing the mean values of both groups with a significance level of 0.05. To measure the level of creative thinking skills used in essay tests. The teacher gave several patterns in sequence and students were asked to make other polamatika that have the same pattern as the problems and count the number of red and white squares. Students were also asked to find formulas for n-th patterns on colored squares and white squares. At the next level students were asked to make a new pattern that is different from the patterns contained in the worksheet.

Some of the polamatika developed in this research are as follows.

2.3.1. Polamatika 1

![Figure 3. Polamatika 1.](image)

To determine the number of square in the next order can be done by making a pattern from existing data as in the following pattern list:
### Red squares

| n | 1 | 2 | 3 | 4 | 5 | 6 | n |
|---|---|---|---|---|---|---|---|
| ∑ | (2x1)-1 | (2x2)-1 | (2x3)-1 | (2x4)-1 | (2x5)-1 | (2x6)-1 | 2n - 1 |

### White squares

| n | 1 | 2 | 3 | 4 | 5 | 6 | n |
|---|---|---|---|---|---|---|---|
| ∑ | (1-1)^2 | (2-1)^2 | (3-1)^2 | (4-1)^2 | (5-1)^2 | (6-1)^2 | (n-1)^2 |

Based on the pattern shown in the table above, it is known that the n-th pattern of polamatika in figure 3 is as follows:
- Total squares: \( n \times n = n^2 \)
- Red squares: \( 2n - 1 \)
- White squares: \( (n - 1)^2 \)

### 2.3.2. Polamatika 2

#### Figure 4. Polamatika 2.

To determine the number of square in the next order can be done by making a pattern from existing data as in the following pattern list:

### Red squares

| n | 1 | 2 | 3 | 4 | 5 | 6 | n |
|---|---|---|---|---|---|---|---|
| ∑ | 1x2 | 2x3 | 3x4 | 4x5 | 5x6 | 6x7 | n(n+1) |
|   | \( \frac{1}{2} \) | \( \frac{2}{2} \) | \( \frac{3}{2} \) | \( \frac{4}{2} \) | \( \frac{5}{2} \) | \( \frac{6}{2} \) | \( \frac{n(n+1)}{2} \) |

### White squares

| n | 1 | 2 | 3 | 4 | 5 | 6 | n |
|---|---|---|---|---|---|---|---|
| ∑ | 1x0 | 2x1 | 3x2 | 4x3 | 5x4 | 6x5 | n(n-1) |
|   | \( \frac{1}{2} \) | \( \frac{2}{2} \) | \( \frac{3}{2} \) | \( \frac{4}{2} \) | \( \frac{5}{2} \) | \( \frac{6}{2} \) | \( \frac{n(n-1)}{2} \) |

Based on the pattern shown in the table above, it is known that the n-th pattern of polamatika in figure 4 is as follows:
- Total squares: \( n \times n = n^2 \)
- Red squares: \( \frac{n(n+1)}{2} \)
- White squares: \( \frac{n(n-1)}{2} \)
Meanwhile, to measure the level of student activity, activity analysis was carried out during learning with the RBL based on predetermined indicators. Moreover, interviews were also conducted to find out the portrait phase of students' creative thinking skills in solving polamatika problems.

3. Results and Discussion

3.1. Results

Creative thinking skills require students to provide various alternative solutions from various perspectives in solving to the problems using the provided information. Besides, students must be required to learn actively during the learning process. Students’ creative thinking skills can be seen in learning outcomes. The average value of student learning outcomes is used to determine the improvement of creative thinking skills using the RBL model. Meanwhile, the average value of student activity is used to know the student learning activities during the learning process by using the RBL model based on student's activities criteria.

3.1.1. The results of the validity and reliability test

Before the test is given, the validity and reliability test are done. The validity test was processed with the Statistical Package for the Social Science (SPSS) program for windows version 25.0. The decision on the validity of the test is seen from the Pearson correlation value from the SPSS analysis output. Validity test results can be shown in the following table.

**Table 5.** The Results of the validity test: correlations.

| Item_1  | Item_2  | Item_3  | Item_4  | Item_5  | Item_6  | Item_7  | Item_8  | Total  |
|---------|---------|---------|---------|---------|---------|---------|---------|--------|
| Pearson Correlation | 1.000** | 1.000** | .838** | .801** | .909** | .768** | .444 | .951** |
| Sig. (2-tailed) | .000 | .000 | .001 | .002 | .000 | .004 | .149 | .000 |
| N | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| Item_2 Pearson Correlation | 1.000** | 1.000** | .838** | .801** | .909** | .768** | .444 | .951** |
| Sig. (2-tailed) | .000 | .000 | .001 | .002 | .000 | .004 | .149 | .000 |
| N | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| Item_3 Pearson Correlation | 1.000** | 1.000** | .838** | .801** | .909** | .768** | .444 | .951** |
| Sig. (2-tailed) | .000 | .000 | .001 | .002 | .000 | .004 | .149 | .000 |
| N | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| Item_4 Pearson Correlation | .838** | .838** | .838** | 1 | .867** | .866** | .870** | .614* | .936** |
| Sig. (2-tailed) | .001 | .001 | .001 | .000 | .000 | .000 | .034 | .000 |
| N | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| Item_5 Pearson Correlation | .801** | .801** | .801** | .867** | 1 | .881** | .834** | .843* | .933** |
| Sig. (2-tailed) | .002 | .002 | .002 | .000 | .000 | .001 | .000 | .001 |
| N | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| Item_6 Pearson Correlation | .909** | .909** | .909** | .866** | .881** | 1 | .845** | .488 | .947** |
| Sig. (2-tailed) | .000 | .000 | .000 | .000 | .000 | .001 | .108 | .000 |
| N | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| Item_7 Pearson Correlation | .768** | .768** | .768** | .870** | .834** | .845** | 1 | .577* | .883** |
| Sig. (2-tailed) | .004 | .004 | .004 | .000 | .001 | .001 | .049 | .000 |
| N | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| Item_8 Pearson Correlation | .444 | .444 | .444 | .614* | .843** | .488 | .577* | 1 | .647* |
| Sig. (2-tailed) | .149 | .149 | .149 | .034 | .001 | .108 | .049 | .023 |
| N | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| Total Pearson Correlation | .951** | .951** | .951** | .936** | .935** | .947** | .883** | 1 | .647* |
| Sig. (2-tailed) | .000 | .000 | .000 | .000 | .000 | .000 | .023 |
| N | 12 | 12 | 12 | 12 | 12 | 12 | 12 |

**Correlation is significant at the 0.01 level (2-tailed).**

*. Correlation is significant at the 0.05 level (2-tailed).
Based on table 4, it can be seen that \( r_{count} \) for question number 1 is 0.951, number 2 is 0.951, number 3 is 0.951, number 4 is 0.936, number 5 is 0.935, number 6 is 0.947, number 7 is 0.883, and number 8 is 0.647. All of the items give the value of \( r_{count} > r_{table} \) with \( N = 12 \) that is 0.547, so it can be said that the eight items are valid and can be used.

| Table 6. The Results of the reliability test: reliability statistics. |
|---------------------------------------------------------------|
| Cronbach's Alpha Based on Standardized Items | N of Items |
| .963 | .967 | 8 |

From table 5 it is known that N of items (number of items) is 8 (eight) items with Cronbach's Alpha value is 0.963. Because the Cronbach's Alpha value is greater than 0.06, it can be concluded that all of the items are reliable and consistent.

3.1.2. Distribution of students' creative thinking skills based on pretest
Before the implementation of learning materials based on research-based learning, the researcher gave a pretest to the control class and the experimental class to find out the similarity of variants between the control class and the experimental class. The following graphs show the distribution of students' creative thinking skills from pretest results in each indicator.

**Figure 5.** Distribution of students' creative thinking skills in each indicator of the control class based on pretest.

**Figure 6.** Distribution of students' creative thinking skills in each indicator of the experimental class based on pretest.
Based on the results of the pretest analysis between the two classes, it can be seen both classes have the same variance. The results showed the creative thinking skills of the control class gaining poor category is 28.2%, poor category is 44.4%, good category is 45.6% and very good category is 2.4%, while for the experimental class gaining poor category is 26.7%, poor category 44.6%, good category is 23.3% and very good category is 5.4%. The results of both classes can be seen in Figure 5 and Figure 6. With this distribution, it will help our knowledge to interpret the significant effect of research-based learning for students’ creative thinking skills in solving polamatika problems.

Furthermore, pretest results were analyzed based on the level of students’ creative thinking skills in solving polamatika problems between the control class and the experimental class as in the table 6 bellow.

**Table 7.** Comparison of creative thinking skill levels of pretest.

| Level         | Control Class | Experimental Class |
|---------------|---------------|--------------------|
| Level 0 (Not Creative) | Sum 8 %25.8 | Sum 7 %23.3 |
| Level 1 (Less creative) | Sum 7 %22.6 | Sum 7 %23.3 |
| Level 2 (Fairly creative) | Sum 4 %12.9 | Sum 5 %16.7 |
| Level 3 (Creative) | Sum 10 %32.3 | Sum 8 %26.7 |
| Level 4 (Very Creative) | Sum 2 %6.5 | Sum 3 %10.0 |

Figure 7 shows that both classes have the same level of creative thinking skills. Based on the results of the analysis it can be seen that the level of creative thinking skills of the control class with the category of not creative is 25.8%, less creative is 22.6%, fairly creative is 12.9%, creative is 32.3% and very creative is 6.5%, while for the experimental class with the less creative category is 23.3%, fairly creative is 16.7%, creative is 26.7% and very creative is 10%.

Next, a homogeneity test is performed to find out whether the research subjects in the control class and the experimental class are homogeneous based on the pretest result. A homogeneity test analysis was performed with SPSS v.25 software. Both classes can be the subject of the research if homogeneity test results show sig. value > 0.05 at the significance level of 0.05, which means that both classes are homogeneous or have the same initial ability. Homogeneity test results can be seen in table 7 bellow.
Table 8. The analysis of the homogeneity of pretest.

| Pretest                        | Levene Statistic | df1 | df2 | Sig.   |
|-------------------------------|------------------|-----|-----|--------|
| Based on Mean                 | 0.000            | 1   | 59  | 0.991  |
| Based on Median               | 0.000            | 1   | 59  | 0.992  |
| Based on Median and with adjusted df | 0.000          | 1   | 58,794 | 0.992   |
| Based on trimmed mean         | 0.000            | 1   | 59  | 0.999  |

Based on the test of Homogeneity of Variance table, it can be seen that the mean probability value is 0.991. Sig value > 0.05 which means that the pretest results between the control class and the experimental class have insignificant differences or it is said that the variants of both classes are homogeneous. Thus, the treatment can be continued, that is the control class with the implementation of conventional models and the experimental class with the implementation of the RBL model.

3.1.3. Distribution of students' creative thinking skills based on posttest

Students' creative thinking skills are measured based on the results of the posttest, that is the answer to the essay question. Students' answers were analyzed on a Likert scale with a range of 1 to 4 according to aspects and indicators of creative thinking skills in solving polamatika problems. The results of the analysis are calculated on the percentage of each assessment indicator to determine the distribution of students' creative thinking skills.

**Figure 8.** Distribution of students' creative thinking skills in each indicator of the control class based on posttest.

**Figure 9.** Distribution of students' creative thinking skills in each indicator of the experimental class based on posttest.
Based on the results of the posttest analysis between the two classes, it can be seen that both classes have different levels of creative thinking skills. The results showed that overall in the aspects of creative thinking skills of the control class with a very good category is 22.6%, good is 29.4%, fair is 45.6% and poor is 2.4%, while for the experimental class with a very good category is 52.9%, good is 20.8% and fair is 26.3%. The results of both classes can be seen in Figure 8 and Figure 9. With this distribution, it proves that the implementation of learning materials based on research based learning can improve students' creative thinking skills in solving polamatika problems.

As for the comparison of the level of creative thinking skills of students in solving polamatika problems in each class the following data is obtained.

| 3.1.1. Level | Control Class | Experimental Class |
|--------------|---------------|---------------------|
| Level 0 (Not Creative) | 3 | 9.7 | 0 | - |
| Level 1 (Less creative) | 6 | 19.4 | 2 | 6.7 |
| Level 2 (Fairly creative) | 5 | 16.1 | 3 | 10 |
| Level 3 (Creative) | 13 | 45.2 | 14 | 46.7 |
| Level 4 (Very Creative) | 3 | 9.7 | 11 | 36.7 |

Figure 10 shows that the two classes have different levels of creative thinking skills. Based on the results of the analysis it can be seen that the level of creative thinking skills of the control class with the category of not creative is 9.7%, less creative is 19.4%, fairly creative is 16.1%, creative is 45.2% and very creative is 9.7%, while for the experimental class with the category of less creative is 6.7%, fairly creative is 10%, creative is 46.7% and very creative is 36.7%. At the very creative level, there is a significant difference in the percentage of creative thinking skills between the control class and the experimental class, ie the experimental class is much higher than the control class. With this distribution, it proves that the implementation of learning materials based on research-based learning can improve students' creative thinking skills in solving polamatika problems.
Furthermore, inferential statistical analysis is performed to determine the differences in the implementation of learning materials based on research-based learning by independent sample t-test. Previously, the researchers conducted a prerequisite test, which is the normality test.

**Table 10.** The analysis of the normality test of both class for the posttest.

| Class           | Kolmogorov-Smirnov | Shapiro-Wilk |
|-----------------|---------------------|--------------|
|                 | Statistic df Sig.   | Statistic df Sig. |
| Post Test       | Control Class       | .162 31 .038 | .950 31 .152 |
|                 | Experimental Class  | .128 30 .200* | .947 30 .140 |

* This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Based on table 9 above, with a significance level of 0.05, it is known in the Saphiro Wilk column that the control class has a significance value of 0.152 (Sig.> 0.05) so that it is said to have a normal distribution. Likewise, in the experimental class which has a significance value of 0.140 (Sig.> 0.005) so that the experimental class posttest data has a normal distribution. From the results of the normality test above, the data of both the control class and the experimental class are qualified for an independent sample test.

**Table 11.** The comparison of the post-test score of experimental class and control class score using independent sample t-test.

| Levene's Test for Eq. of Var | t-test for Equality of Means |
|------------------------------|------------------------------|
| F Sig. t df Sig. (2-tailed) Mean Difference Std. Error Difference 95% Confidence Interval of the Difference Lower Upper |
| Equal variances assumed 1.909 .172 -4.217 59 .000 -13.734 3.257 -20.251 -7.218 |
| Equal variances not assumed -4.230 58 .000 -13.734 3.247 -20.235 -7.234 |

Based on table 10 above, it is known that with a significance level of 0.05 Sig (2-tailed) value from the posttest score for the control class and experimental class of 0,000 (p <0.05), this means that there are differences in the average significant between the creative thinking skills of the control class students and the experimental class. It implies that the implementation of learning materials based on RBL significantly affected the students' creative thinking skill in solving polamatika problem.

3.1.4. Students activities during RBL implementation

The level of student activity was observed using an activity sheet that followed the indicators of the RBL learning model.
Figure 11. The Distribution of student activity under the implementation of RBL.

Figure 11 shows that the students' activities in the experimental class that implementing learning materials based on research-based learning had activeness in each indicator of RBL activity with a fair category is 16%, good is 32.3% and very good is 51.7%.

Whereas the activeness of students based on the activeness category during the learning process can be seen in the following graph.

Figure 12. The level of students' activity under the implementation of RBL.

Based on Figure 12, the observation of RBL activity involved 31 students who were in the experimental class. It was found that 60% of students reached the very active criteria, 20% of students reached the active level, 16.7% at hesitate and the remaining 3.3% were at the inactive level. It can be concluded that the implementation of research-based learning materials can increase student activity during the learning process in solving polamatika problems. At last, it can improve the students’ creative thinking skills.

3.1.5. Student test results

From some posttest results, 3 samples were taken that represented creative thinking skills in the less creative, creative and very creative categories.
3.1.5.1. Student test results with less creative category

Students with the creative thinking skills category are less creative, could make the appropriate polamatika and gave a good coloring. Students could also determine the number of red and white squares based on the pattern. But students weren’t able to find the n-th pattern formula well. Besides that, students who are less creative were also able to make simple polamatika that couldn’t be determined yet. In other words, he has not succeeded in making a new polamatika and to complete these images requires a long time.

3.1.5.2. Student test results with creative category

The student could make the appropriate polamatika and gave a good coloring.
Students who have creative thinking skills with creative categories could make the appropriate polamatika and gave a good coloring. Students could also determine the number of red and white squares based on the pattern. Creative students could determine the n-th pattern of the red squares, but were able to determine the n-th pattern formula for white squares, they just could assume that white squares are the result of subtracting all squares with red squares. Creative students could make simple polamatika that has not been shown by the teacher during the learning process although it can’t be determined yet.

3.1.5.3. Student test results with very creative category

The student could make the appropriate polamatika and gave a good coloring. The student was able to determine the formula pattern for red squares, but couldn’t determine the formula pattern for white squares. The student could make a simple drawing that couldn’t be determined yet.
Figure 15. Student test results with very creative category.

Students who have creative thinking skills in the very creative category categories could make the appropriate polamatika and gave a good coloring. Students could also determine the number of red and white squares based on the pattern. Very creative students could determine the formula to the n-th pattern for red square and white square well. Creative students could make complicated polamatika and have never been displayed by the teacher during the learning process and could determine the n-th pattern formula for a red square. He managed to create a new pattern and the time required was faster than other students.

3.1.6. The portrait phase of students’ creative thinking skills
To find out the portrait phase of the students’ creative thinking skills in solving polamatika problems, researchers conducted interviews with students that have creative thinking skills level in very creative category. The data obtained through the interview process were transcribed below.

(T: Teacher, S: Student)
T: What is the question about?
S: A square and draw a pattern.
T: Is this problem easy, medium or difficult? (researchers dig deeper about the character of the questions).
S: Medium ma’am.
T: Can you continue the pattern presented?
S: Yes, ma’am. (student completion results are complete and correct).
T: Explain the stages of the activity to solve the polamatika problem!
S: After continuing the pattern, I color the pattern and write down the sum of each red and white square under each picture. Then I determine the n-th pattern formula. Finally, I continue to make a new polamatika and determine the pattern formula.
T: Good, how do you give color to each pattern in the problem?
S: I gave the color following the pattern reference contained in the problem.
T: Okay, next, do you understand the numbers under each box?
S: Number of red and white squares.
T: Next, can you guess how many red squares are on the 8th pattern?
S: (students think, then start trying to count on a worksheet).
T: Explain your calculations.
(Students calculated the formula for a particular pattern by considering the mathematical symbols in all the patterns contained in the problem and also consider the linear increase of each pattern increase, so they get the right answer)

S: Pattern 1 pairs 0 and 1 red and white, pattern 2 pairs 4 and 0, pattern 3 pairs 8 and 1, pattern 4 pairs 12 and 4. The red is a multiple of 4. Whereas the white is the square of the sequence of the reduced pattern 2. So the pattern the 8 whites are $6 \times 6 = 36$.

T: Good. How do you make this new polamatika? (the teacher refers to the polamatika created by student)

S: (the student trying to explain).

I made a new polamatika that was different from the problem and then I tried to determine the pattern formula, but I had difficulty determining the nth pattern formula for a white square.

T: Fine, thanks for the explanation.

The student's portrait phase of creative thinking flow is as follows.

![Diagram](image)

**Figure 16.** The student's portrait phase of creative thinking.

### 3.2. Discussion

This research was done to analyze the implementation of learning materials based on Research-Based Learning to improve students' creative thinking skills in solving polamatika problems. The findings of this research indicate that the implementation of learning materials based on Research Based Learning has a significant effect on improving students' creative thinking skills. The results from postest showed the students creative thinking skills of control class with the category of not creative is 9.7%, less creative is 19.4%, fairly creative is 16.1%, creative is 45.2% and very creative is 9.7%, whereas for the experimental class with the less creative category is 6.7%, fairly creative is 10%, creative is 46.7% and very creative is 36.7%. From these results, the experimental class students showed their creative thinking skills higher than the control class students.

These results are in line with the results of research conducted by several previous researchers who concluded that RBL can effectively improve student learning outcomes [3, 16, 17]. The learning achievement in the experimental class applying RBL was better than the control class applying conventional learning [9]. This shows that the implementation of RBL is effective in increasing students’ learning achievement and students' creative thinking skills. The steps of this learning model emphasize student-centered learning and under the supervision of the teacher, students are encouraged to think creatively and develop problem-solving strategies based on experimental experiences and literature review. It implies that cognitive students always work actively in solving given problems. The awareness of the impact of students 'creative thinking skills shows that when we can improve students' creative thinking skills, it will have implications for improving student learning outcomes [6]. Some factors that influence students' creativity are challenges, availability of time, and the ability to solve problems and make decisions systematically and dare to take risks [5].

Research has proven that when RBL is applied properly, it can increase content retention and increase students' positive responses to learning to provide students with the ability to think academically. This also contributes to the existence of positive student activities under the RBL implementation [4]. The application of RBL is proven to increase students' creative thinking skills [7].
Data obtained through the process of observation of student activities shows that students give positive responses. The results of the analysis of RBL activity in the experimental class with inactive category is 6.7%, hesitate is 13.3%, active is 36.7%, and very active is 43.3%. This means that the implementation of learning materials based on Research-Based Learning can increase student activity during the learning process. Finally, its implementation can improve students' creative thinking skills in solving polamatika problems.

4. Conclusions
The implementation of learning materials based on Research-Based Learning can improve students' creative thinking skills. This is evidenced by the results of the t-test which showed significant differences in the posttest results between the control class and the experimental class. Besides, the implementation of learning materials based on Research-Based Learning can also increase student activity so that the learning process more effective.

The difference in students' portrait phase of creative thinking shows that students' creative thinking skills vary greatly depending on the ability of each student.

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References
[1] Arikunto S 2013 Research Procedure: a Practical Approach (Jakarta: Rineka Cipta)
[2] Creswell J W 2018 Research Design: Qualitative, Quantitative and Mixed Method Approaches (Yogyakarta: Pustaka Belajar)
[3] Dafik, Sucianto B, Irvan M and Rohim M A 2019 The analysis of student metacognition skill in solving rainbow connection problem under the implementation of research-based learning model International Journal of Instruction 12(4) 593–610
[4] Guinness P 2012 Research-based learning: teaching development through fieldschools Journal of Geography in Higher Education 36(3) 329–339
[5] Hussen S, Dafik, Monalisa L A, Murtikusuma R P and Oktavianingtyas E 2019 Combinatorial thinking and creativity skills in solving a colored-square paving decoration problem Journal of Physics: Conference Series 1211 012062
[6] Lin C S and Wu R Y W 2016 Effects of web-based creative thinking teaching on students' creativity and learning outcome Eurasia Journal of Mathematics, Science and Technology Education 12(6) 1675–1684
[7] Nazula N H, Dafik and Slamin 2019 The profile of students’ creative thinking skills in solving local antimagic vertex coloring problem in research based learning Journal of Physics: Conference Series 1211(1) 012109
[8] Poonpan S and Suwanmankha S 2005 Indicators of research - based learning instructional process: a case study of best practice in a primary school AARE Annual Conference
[9] Rohim M A, Dafik, Slamin and Sucianto B 2019 The analysis of implementation of research based learning implementation in developing the students’ creative thinking skill in solving dominating set problem IOP Conference Series: Earth and Environmental Science 243 012143
[10] Rotherham A J and Willingham D 2009 21st Century skills: the challenges ahead Educational Leadership 67 16–21
[11] Salimi M, Susiani T S and Hidayah R 2017 Research-based learning as alternative learning model in education management institutions Jurnal Pendidikan Sekolah Dasar 3 1284
[12] Singh V 2014 Research based learning: an igniting min International Journal for Research in Education(IJRE) (Impact Factor 1.5) 3(6) 21–24
[13] Siswono T Y E 2011 Level of student’s creative thinking in classroom mathematics Educational Research and Reviews 6(7) 548–553
[14] Srikoon S, Bunterm T, Samranjai J and Wattanathorn J 2014. Research synthesis of research-based learning for education in thailand Procedia - Social and Behavioral Sciences 116 913–917

[15] Sternberg R J 2003 Creative thinking in the Classroom Scandinavian Journal of Educational Research 47(3) 325–338

[16] Suntusia, Dafik and Hobri 2018 The effectiveness of research based learning in improving students’ achievement in solving two-dimensional arithmetic sequence problems International Journal of Instruction 12 17–32

[17] Syaibani H A, Dafik and Hobri 2017 The analysis of student’s creative thinking skills in solving “rainbow connection” problem through research based learning The International Journal of Social Sciences and Humanities Invention 4(7) 3783–3788

[18] Tohir M, Abidin Z, Dafik and Hobri 2018 Students creative thinking skills in solving two dimensional arithmetic series through research-based learning Journal of Physics: Conference Series 1008 012072

[19] Widayati D T, Luknanto D, Rahayuningsih E, Sutapa G, Harsono, Sancayaningsih R P and Sajarwa 2010 General Guidelines for Research-Based Learning (Yogyakarta: Universitas Gajah Mada)