The analysis of students' creative-innovative thinking skills in solving total dominator coloring under the implementation of research-based learning model

A R Lazuardi\textsuperscript{1,2}, Slamin\textsuperscript{1,3}, Dafik\textsuperscript{1,2}
\textsuperscript{1}CEREBEL University Of Jember, Indonesia
\textsuperscript{2}Department of Mathematics Education Post Graduate, University of Jember, Indonesia
\textsuperscript{3}Faculty of Computer Science, University of Jember, Indonesia

E-mail: 190220101019@students.unej.ac.id

Abstract. Thinking skills are very important in all aspects of life, especially education. In the era of 21st century skills, creative innovative thinking skills, play a serious role in improving students' life skills. This study aims to determine the application of research based learning (RBL) in improving students' creative innovative thinking skills in solving the total dominator coloring. Mixed methods is the research method used in this study. The research subjects consisted of two classes, namely 24 students in the control class and 21 students in the experimental class. The two classes were given a different treatment. Control class using PBL model and experimental class using RBL student worksheets. Homogeneity test results on problems pre-test showed a significance value of 0.067 > 0.05, which means that the two classes are homogeneous. The results of the independent sample t-test showed the results of 0.000 < 0.05, which means significant. The conclusion obtained from this study is that there is an increase in students' creative innovative thinking skills after the application of research-based learning models in solving total dominator coloring problems.

1. Introduction
Mathematics is a basic science that is needed for the development of science and technology. The development of other sciences, such as physics, biology, economics, and even the social sciences, can not be separated from the role of mathematics. Mastery of mathematics will be very important for the nation's successors for the progress of a country in the future. Mathematics learning is needed to equip the nation's future with the ability to think critically, logically, analytically and systematically. Thinking is a process of activity to find truth and skills to acquire knowledge. One of the thinking skills in solving mathematical problems is creative and innovative thinking skills.

According to Yudha [1] Creative innovative means a person's ability to find new things. Developing creative innovative thinking skills in students is very important, given the increasingly complex problems in all aspects of life. Treffinger in [2] provides reasons why creative thinking is very important for students: (1) Creative thinking helps children to be more successful in solving problems. This is because
creative thinking is the ability to see various possible solutions to a problem, (2) Creative thinking creates possibilities for solving problems that arise in the future, (3) Creative thinking can have major consequences in life that enables humans improve the quality of life, (4) Creative thinking can lead to great satisfaction and pleasure.

The government through kemenristekdikti has formulated the skills that every student must possess according to the 21st century skills, namely creative and innovative, critical thinking and problem solving, collaboration, and communication. This shows that creative and innovative thinking skills are very important for every student. To train and improve students' creative innovative thinking skills, it can be done by giving questions the total dominator coloring in combinatorics courses which require learning that has feedback between teachers and students.

The definition of total dominator coloring of a graph $G$ is a proper coloring where every point on $G$ dominates every point from some color classes [3]. The least number of color classes from the total dominator coloring is called the total dominator chromatic number which is denoted by $\chi^*_d(G)$. In the concept of total dominator coloring, students are expected to be able to make discoveries related to total dominator coloring. Students are asked to determine the minimum number of color classes on a graph that meets the total dominator coloring requirements. Before determining the minimum color class that meets the requirements for total dominator coloring, students are asked to determine the dominator coloring of a graph and label it. Students are tasked with determining the members of the existing color classes and checking whether the points on the graph that have been given a color dominate each point from several color classes. If yes, then the graph is called the total dominator of colors so that the chromatic number can be calculated. At this stage, students are required to think creatively and innovatively so that the results of the graph findings are truly scientific and different from other students.

One learning model that leads to creative innovative thinking skills is the Research Based Learning (RBL) model. According to Maylisa [4] RBL is a learning method that uses contextual learning, authentic learning, problem-solving, cooperative learning, hands on & minds on learning, and an inquiry discovery approach. The target of implementing RBL is to encourage the creation of higher order thinking skills in lecturers and students. Students are not only stuffed with information and knowledge, but must be brought to a higher level, namely creating or communicating. Syntax of the Research Based Learning model according to Arifin in [5], namely there are three main groupings of steps that must be in the Research-Based learning stage, namely: 1) Exposure stage, 2) Experience stage, and 3) Capstone stage. In this study, there are three aspects to compute students' creative innovative thinking skills expressed by Al Jabbar [6], namely 1) Creative Thinking, 2) Working creatively with others, 3) Implementation of Innovation. From these three aspects, indicators of creative innovative thinking are developed in accordance with the RBL syntax as in the table below.

| RBL Syntax      | Aspects of creative innovative thinking | Indicator                                                                 |
|-----------------|----------------------------------------|---------------------------------------------------------------------------|
| Exposure Stage  | Think Creatively                       | Research 1                                                                |
|                 |                                        | 1) Students are able to find ideas related to total dominator coloring    |
|                 |                                        | 2) Students are able to create their ideas and determine the total         |
According to Siswono in [7] in addition to the indicators of innovative creative thinking skills above, there are indicators of creative innovative thinking skills levels in table 2.

**Table 2. Indicators of the level of creative innovative thinking skills.**

| Score | Interpretation                  |
|-------|---------------------------------|
| 0 – 5 | Level 0 (Uncreative innovative) |
| 6 – 10| Level 1 (Lacking creative innovative) |
| 11 – 15| Level 2 (Suitable creative innovative) |
| 16 – 20| Level 3 (Creative innovative)    |
| 21 – 25| Level 4 (Very creative innovative) |

Several previous studies such as those of Al Jabbar [6] and Sulistiyono [8] related to creative innovative thinking skills using the RBL model showed positive results on several different materials. Other studies using RBL models such as Tohir [9], Hastuti [10], Wardani [11], and Nazula [12] have also shown positive results for different thinking skills. The resulting a mathematics learning tool is quite effective in improving students’ creative innovative thinking skills. In this study, researchers developed learning tools using the RBL model which aims to determine the influence of students' creative innovative thinking skills in solving total dominator coloring problems.
2. Research Methods

This research is a mixed method research. The combination research method is a research design that involves data collection and analysis techniques through a mixture of qualitative and quantitative processes [13]. This research will use a sequential exploratory design which is a combination research with the first stage of collecting and analysing qualitative data, the second stage is collecting and analyzing quantitative data to make conclusions from the research results in the initial phase.

This study aims to develop mathematics learning tools based on research based learning. The mathematics learning products are student worksheets and tests. The development of the tools to be implemented refers to the 4-D development model from Thiagarajan [14]. The study was conducted to determine the effect of the research-based learning model with the students' creative innovative thinking skills in solving the total dominator coloring problems.

In this study students were given a different treatment. The experimental class students used the RBL model and the control class students used the PBL model. The choice of the PBL model as a comparison is because this model has a good structure in improving students' thinking skills such as research by Harjito [15] and Karimah [16] which showed positive results.

Table 3. Research method.

| Class        | Pre test | Treatment | Post test |
|--------------|----------|-----------|-----------|
| Experiment class | R₁      | X₁        | R₂        |
| Control class  | R₃      | X₂        | R₄        |

Note :
R₁ and R₃  : The two group were observed by using pre-test to know the initial ability.
R₂ and R₄  : Classroom post test result
X₁         : Learning using RBL student worksheet
X₂         : Learning using problem based learning

2.1 Population

The population in this study was the fifth semester students of Mathematics Education at the University of Jember who took combinatorics courses. The research sample consisted of 21 students in class A as the experimental class and 24 students in class B as the control class.

2.2 Instruments

The instruments used in this study were pretest, posttest, and interviews. The observation sheet uses a rating scale of 0-4, namely 4 for highly creative innovative, 3 for creative innovative, 2 for appropriate creatives innovative, 1 for lacking innovative creative, and 0 for uncreative innovative. All instruments used have been validated by experts.

2.3 Task

In this study students were given assignments in the form of a pretest, posttest, and worksheets in accordance with the indicators. Students in the control class were given a pretest and posttest, while students in the experimental class were given a pretest, posttest and student worksheets. Students are asked to label points and edges, determine coloring, determine color classes, and determine the total dominator chromatic number of the graph.
2.4 Data Analysis
Collecting data in this study is to select the sample class used as research subjects in the form of the experimental class and the control class. The pre-test is carried out at the beginning of the lesson and the
post-test is carried out at the end of the lesson. If the data in this study were normally distributed and homogeneous, then using data analysis techniques in the form of independent t-test. Measuring the level of reliability of data collection tools in this study using Alpha Cronbach. The homogeneity test of variance uses SPSS. The independent t-test in this study used SPSS by entering the post-test data for the class used experimentally. The hypothesis are formulated in the form of a pair of null hypotheses ($H_0$) and alternative hypotheses ($H_1$). With the test criteria accept $H_0$ if the significance value or probability value > 0.05 then $H_0$ is accepted and $H_1$ if the significance value or probability value 0.05 then $H_0$ is rejected.

3. Research Findings

The first step the researcher do was to test the validity and reliability of the post-test questions that would be tested on students to determine the level of accuracy of the measuring instrument in performing the measurement function. The sample used in the validity and reliability test was 45 students. The following will explain the results of the validity and reliability tests carried out by the research subjects.

From the result on table 5, the value of the $r_{count}$ on question 1 was 0.949; $r_{count}$ on question 2 was 0.889; $r_{count}$ on question 3 was 0.909; while $r_{table}$ for n = 45 was 0.372. So that it can be concluded that $r_{count}$ on question 1-3 > $r_{table}$ thus all question were valid. Based on table 4, the reliability value was 0.881 and $r_{table}$ from the significance level was 0.01 with dk = N - 2 = 43, $r_{table}$ = 0.380. Therefore $r_{count}$ > $r_{table}$ so the instruments were reliable.

| Reliability Statistics |
|------------------------|
| Cronbach's Alpha       |
| N of Items             |
| .821                   |

The pre-test and post-test scores used were taken from the experimental class and the control class. Interview, observation, and ordinal data analysis were used to obtain qualitative data, while the t-test was used to obtain quantitative data. Different treatments were given to the class, the experimental class used RBL based student worksheet while the control class used problem based learning.

The pre-test and post-test were obtained from two classes total 45 students. The pre-test was used to determine the initial ability of students to think creative innovative about the total dominator coloring problem. The pre-test and post-test questions subsist of 3 aspects with 7 indicators of creative innovative thinking abilities. After learning using student worksheet based on the RBL method, students are given post-test questions in the form of questions to compute students' creative innovative thinking abilities.

The pretest data obtained in the experimental class and control class shows that the data variable is homogeneous and normally distributed. From table 6 we can see that the significance value of the normality test is 0.141 > 0.05, so it can be concluded that the pre-test data can be normally distributed. In table 7 we can also see that the significance value is 0.067 > 0.05, that means the pre-test data obtained is homogeneous.
Table 5. Result of question validity.

| S1        | S2         | S3         | SKOR TOTAL |
|-----------|------------|------------|------------|
| Pearson Correlation | 1 | .809** | .769** | .949** |
| Sig. (2-tailed)        | .000 | .000 | .000 |
| N            | 45         | 45         | 45         |
| Pearson Correlation | .809** | 1 | .709** | .889** |
| Sig. (2-tailed)        | .000 | .000 | .000 |
| N            | 45         | 45         | 45         |
| Pearson Correlation | .769** | .709** | 1 | .909** |
| Sig. (2-tailed)        | .000 | .000 | .000 |
| N            | 45         | 45         | 45         |
| Pearson Correlation | .949** | .889** | .909** | 1 |
| Sig. (2-tailed)        | .000 | .000 | .000 |
| N            | 45         | 45         | 45         |

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

Table 6. Result of normality test of pretest.

| One-Sample Kolmogorov-Smirnov Test |
|-----------------------------------|
| Unstandardized Residual           |
| N       | 45 |
| Normal Parameters<sup>a,b</sup>   | Mean | 14.33 |
|         | Std. Deviation | 2.804 |
| Most Extreme Differences          | Absolute | .117 |
|         | Positive | .117 |
|         | Negative | -.083 |
| Test Statistic                     | .117 |
| Asymp. Sig. (2-tailed)            | .141<sup>c</sup> |

<sup>a</sup>. Test distribution is Normal.
<sup>b</sup>. Calculated from data.
<sup>c</sup>. Lilliefors Significance Correction.
Table 7. Result of homogeneity test.

| Levene Statistic | df1 | df2 | Sig.  |
|------------------|-----|-----|-------|
| 3.539            | 1   | 43  | .067  |

Based on figure 2 the percentage of pre-test results from 24 control class students at each level of creative innovative thinking, among others, for the uncreative innovative levels of 0%, 33% lacking creative innovative, 30% suitable creative innovative, creative innovative by 26%, and very creative innovative at 11%. Meanwhile, the percentage of the pre-test results from 21 students in the experimental class at each level of creative innovative thinking, among others, for the uncreative innovative level of 0%, lacking creative innovative by 34%, suitable creative innovative by 32%, creative innovative at 23%, and very creative innovative at 11%. The percentage of the pre-test results from experimental class showed at figure 3.

![Creative innovative thinking skills of the control class](image)

Figure 2. The distribution chart of students' creative innovative thinking in the control class based on the pre-test results.

The next step the researcher do was giving treatment to the experimental class and the control class. In the experimental class, student worksheet RBL-based was given, while in the control class, problem-based learning was carried out. The results of the treatment are in the form of student activeness. Figure 4 shows the activity of students during the research based learning. As many as 9% of students were in the inactive category, 10% of students were in the lacking active category, 19% were in the suitable active category, 29% were in the active category, and 33% were in the very active category. Based on these results it can be concluded that students are interested in the learning method given.

After giving treatment, the researcher gave the students a test post to find out the depth of students' understanding of the material given. Figure 5 shows the post test results of the control class students and figure 6 shows the post test results of the experimental class. Based on figure 5 the percentage of post-test results from 24 control class students at each level of creative innovative thinking, among others, for the uncreative innovative levels of 0%, 29% lacking creative innovative, 27% suitable creative innovative, creative innovative by 24%, and very creative innovative at 20%. Meanwhile, the percentage of the pre-test results from 21 students in the experimental class at each level of creative innovative thinking, among
others, for the uncreative innovative level of 0%, lacking creative innovative by 21%, suitable creative innovative by 25%, creative innovative at 30%, and very creative innovative at 24%.

![Creative innovative thinking skills of the experimental class](image)

**Figure 3.** The distribution chart of students' creative innovative thinking in the experimental class based on the pre-test results.

![Student activity chart](image)

**Figure 4.** The distribution chart of students' activity when using research based learning method in the experimental class.

From the results obtained, it can be concluded that the ability to think creative innovative in control class students has increased by 9% from 11% to 20% in the very creative innovative category, while in the creative innovative category it has decreased by 2% from 26% to 24%, in the suitable creative innovative category, it also decreased by 3% from 30% to 27%, and in the lacking creative innovative category it decreased from 33% to 29%. The percentage decline that occurred in several categories was due to a
significant increase in the very creative innovative categories, and this is a good result considering that the very creative innovative categories are at the highest level.

**Figure 5.** The distribution chart of students' creative innovative thinking in the control class based on the post-test results.

**Figure 6.** The distribution chart of students' creative innovative thinking in the experimental class based on the post-test results.
In the experimental class there was a very large increase of 14% in students' creative innovative thinking skills, especially in the very creative innovative categories from 11% to 24%. Meanwhile, in the creative innovative category, there was an increase from 23% to 30%, in the suitable creative innovative category it decreased from 32% to 25%, and in the lacking creative innovative category it decreased from 34% to 21%. The percentage decline that occurred in several categories was due to a significant increase in the very creative innovative categories and the creative innovative categories. This shows that students who were initially in the lower level category (category lacking creative innovative) now move up to a higher level (category very creative innovative).

One-Sample Kolmogorov-Smirnov Test

| N  | 45 |
|----|----|
| Normal Parameters<sup>ab</sup> | Mean | 15.00 |
|     | Std. Deviation | 3.162 |
| Most Extreme Differences | Absolute | .095 |
|     | Positive | .095 |
|     | Negative | -.095 |
| Test Statistic | .095 |
| Asymp. Sig. (2-tailed) | .200<sup>c,d</sup> |

a. Test distribution is Normal.
b. Calculated from data.
c. Lilliefors Significance Correction.
d. This is lower bound of true significance

Table 8. Result of normality test of post-test.

| CLASS          | N  | Mean | Std. Deviation | Std. Error Mean |
|----------------|----|------|----------------|-----------------|
| EXPERIMENT CLASS | 21 | 16.86 | 1.797          | .392            |
| CONTROL CLASS  | 24 | 14.25 | 2.345          | .479            |

Furthermore, from the post-test results obtained, an independent sample t-test was carried out to determine the effectiveness of RBL learning tools on students' creative innovative thinking skills. Before the independent sample t-test was carried out, the normality test was first carried out to determine whether the data obtained was normally distributed or not. From the results of the normality test in Table 7, a significance value of 0.200 > 0.05 is obtained, which means that the data obtained is normally distributed.
Furthermore, an independent test was carried out with the results in table 8 and table 9. From table 8 we can see that the mean value of the experimental class was 16.86 greater than the mean value in the control class of 14.25. So it can be concluded that the mean creative innovative thinking skills of the experimental class students are higher than the control class.

**Table 10.** Result of independent sample t-test control and experiment class.

|                      | Levene's Test for Equality of Variances | t-test for Equality of Means | 95% Confidence Interval of the Difference |
|----------------------|----------------------------------------|-----------------------------|------------------------------------------|
|                      | F           | Sig. | t    | df | Mean Difference | Std. Error | Lower | Upper |
| RESULT               |            |      |      |    |                |            |       |       |
| Equal variances      | 1.400      | .243 | 4.139| 43 | .000           | .630       | 1.337 | 3.877 |
| assumed              |            |      |      |    |                |            |       |       |
| Equal variances      | 4.213      | .000 | 42.312| .619| 1.359           | 3.856      |        |       |
| not assumed          |            |      |      |    |                |            |       |       |

In table 9 we can see that the sig. (2-tailed) value is 0.000 < 0.05, which means that there is a significant difference in the post test results of the experimental class and the control class after giving the learning treatment with the RBL method. From the independent sample t-test, it can be concluded that there is an effect of using the RBL method on students' creative innovative thinking abilities. From the results of the pre-test and post-test of the two classes above, when compared, the use of the RBL method shows better results than the PBL method. Students attained more creative innovative thinking levels in the experimental class than in the control class and the number of students who had less creative and innovative thinking levels was higher in the control class. This shows that the RBL method has a major effect on students' learning processes in increasing their creative innovative thinking skills.

Furthermore, interviews were conducted with student representatives from each category to strengthen the results of the data analysis that had been obtained. In addition to the interview, a portrait of the student's phase will also be depicted so that students' thinking patterns can be observed. The phase portrait referred to an illustration of how the students thought while solving a problem. In this research, each student's phase portrait was based on his creative thinking skill by solving the total dominator coloring. Eight objects of experimental and control classes were selected to represent the level of creative innovative thinking skill, but only four subjects were described as the illustrations. The interview was done with the selected subjects to find out their thoughts while solving total dominator coloring.
The results of the interview with student 1 are shown as follows:
Researcher : What was the first step you do to solve the problem?
Student 1  : I am looking for a graph that meets the TDC requirements
Researcher : Then what do you do?
Student 1  : I drew the graph and labeled it. After that I give color to the graph so that it has the proper color.
Researcher : Why did you label the graph first and then give color to the graph?
Student 1  : Because according to my understanding, the basis for coloring must have labeling first. Because from the coloring, the color class will be collected and a dot dominance test will be conducted.
Researcher : Is it okay to do labeling after coloring?
Student 1  : It's okay, but according to me it's not coherent.
Researcher : Okay, what are you doing next?
Student 1  : After the point test, if the graph meets the TDC requirements then I determine the chromatic number.
Researcher : From the problems you worked on, what was the biggest problem you found?
Student 1  : I have a little trouble finding a graph that meets the TDC requirements.
Researcher : Why can it be difficult?
Student 1  : I don't have much literacy related to the kinds and types of graphs that exist, so even when searching on Google it is difficult to find suitable keywords.

Figure 7. The result of student with very creative innovative thinking category.

Figure 8. Phase portrait student with very creative innovative thinking category.
Figure 8 shows a phase portrait of student 1 in the very creative innovative thinking category. It can be seen that he goes from stage 1a straight to stages 1b and 1c. But after from stage 1c, he returns to stage 1b and jumps to stage 2b. Then he goes to stage 2a and back to 2b again. From stage 2b it continues to stage 3a, 3b and ends at 3c.

![Phase Portrait of Student 1](image1)

**Figure 9.** The result of student with creative innovative thinking category.

The results of the interview with student 2 are shown as follows:

| Researcher | Student 2 |
|------------|-----------|
| What was the first step you do to solve the problem? | I'm looking for a graph |
| Then what do you do? | I drew the graph |
| Then? | I color the graph, perform a point domination test, and determine its chromatic number |
| Did you not label the graph that you found? | Yes I did. I also gave it before coloring |
| Why do you work with such steps? | Because from what I learned, the steps are in that order |
| From the problems you worked on, what was the biggest obstacle you found? | Difficult to find a suitable graph |
| Why can it be difficult? | I'm just started learning to graph, so I don't really understand the kinds and types of graphs |

Figure 10 shows a phase portrait of student 2 in the creative innovative thinking category. It can be seen that he starts from stage 1a straight to stage 1b and jumps to stage 2a. From stage 2a it goes straight to stage 2b then to stage 1c and back again to stage 2b. From stage 2b it continues to stage 3a, 3b and ends at 3c.

![Phase Portrait of Student 2](image2)

**Figure 10.** Phase portrait student with creative innovative thinking category.
**Figure 11.** The result of student with suitable creative innovative thinking category.

The results of the interview with student 3 are shown as follows:

Researcher : What was the first step you do to solve the problem?
Student 3  : I'm looking for a graph
Researcher : Then what do you do?
Student 3  : I drew the graph, labeled it, gave coloring
Researcher : Are you sure the graph you find meets the TDC requirements?
Student 3  : Yes, I am sure
Researcher : What makes you sure? You are not performing a dot dominance test on your graph.
Student 3  : I don't have enough time, that's why I can't finish

**Figure 12.** Phase portrait student with suitable creative innovative thinking category.

Figure 12 shows a phase portrait of student 3 in the suitable creative innovative thinking category. It can be seen that he goes from stage 1a straight to stage 1b, 1c and back again to 1b. From stage 1b he jumps to stage 2a. From stage 2a he goes straight to stage 2b then back to stage 2a. Last from stage 2a he jumps to stage 3a and stops.

The results of the interview with student 4 are shown as follows:

Researcher : What was the first step you do to solve the problem?
Student 4  : I'm looking for a graph
Researcher : Then what do you do?
Student 4  : I drew the graph, colored it and determined the chromatic number
Researcher : Did you not label your graph?
Student 4  : I also label it.
Researcher : How do you make sure the graph you find meets the TDC requirements?
Student 4: I'm not sure because I haven't done the point domination test and determined the chromatic number.

Researcher: Why is it like that?

Student 4: I had a hard time finding the graph, so I didn't finish working on it.

Figure 13. The result of student with lacking creative innovative thinking category.

Figure 14. Phase portrait student with lacking creative innovative thinking category.

Figure 14 shows a phase portrait of student 4 in the lacking creative innovative thinking category. It can be seen that he goes from stage 1a straight to stage 1b, 1c and back again to 1b. From stage 1b he jumps to stage 2b. From stage 2b he goes straight to stage 2a then back to stage 1c and stops.

4. Discussion

This study shows the results of improving students' creative innovative thinking skills based on the post test scores obtained. Giving RBL-based student worksheets have a very good impact on students' creative innovative thinking skills. In the experimental class there were 0% of students with uncreative innovative thinking skills, 21% of students with lacking creative innovative thinking skills, 25% of students with suitable creative innovative thinking skills, 30% of students with creative innovative thinking skills, and 24% of students with the ability to think very creative innovative. From the results of the independent sample t-test also got a significant (2-tailed) value 0.000 < 0.05, which means that there is a significant
difference in the post test results of the experimental class and the control class after the application of the RBL model.

5. Conclusion
From the research results it is known that the application of the RBL model has a significant effect on students' creative innovative thinking skills. The higher post test scores were obtained by the experimental class. The increase in the post test score of the experimental class was quite significant when compared to the pre-test results. Therefore, the application of RBL is very good for improving students' creative innovative thinking skills.

Educators or other researchers can apply this RBL model for learning to improve students' thinking skills. It is hoped that other researchers can conduct research on the application of a similar RBL model for other thinking skills such as metacognition abilities, combinatorial abilities, or other thinking abilities that have not been studied before. It is also suggested that other researchers conduct research with different objects, perhaps it can be implemented in elementary to high school students.

Acknowledgement
We thank a lot to the post-graduate department of Mathematics Education, Faculty of Teacher Training and Education, University of Jember, CEREBEL and CGANT research groups, as well as the reviewers who provided suggestions on this paper.

References
[1] Yudha F, Dafik, and Yuliati N 2018 The analysis of creative and innovative thinking skills of the 21st century students in solving the problems of “locating dominating set” in research based learning International Journal of Advanced Engineering Research and Science (IJARES) 5 (3) 163-176

[2] Anggraini D D, Dafik, and Slamin 2019 The analysis of implementation of discovery learning to improve student’s creative thinking skill in local super antimagic total face coloring problem Journal of Physics: Conf. Ser. 1211 012087

[3] Kazemi A P Total dominator chromatic number of a graph. Manuscript, arXiv:1307.7486 [math.CO]

[4] Maylisa I N, Dafik, Hadi A F, Wangguway Y, and Harjito L O 2020 The influence of research-based learning implementation in improving students’ combinatorial thinking skills in solving local irregularity vertex r-dynamic coloring Journal of Phys.: Conf. Ser. 1538 012090

[5] Wangguway Y, Slamin, Dafik, I N Maylisa, and S Kurniawati 2020 The analysis of research-based learning implementation and its affect to the students’ metacognition skill in solving a resolving domination number of a graph Journal of Phys.: Conf. Ser. 1538 012087

[6] Al Jabbar Z L, Dafik, Hadi A F, Wangguway Y, and Sulistiyono B 2020 The analysis of problem-based learning implementation and its effect on students creative innovative skills in solving rainbow antimagic coloring based on cognitive style Journal of Phys.: Conf. Ser. 1538 012089

[7] Suni D M O, Dafik, Tirta I M, Wangguway Y, and Mukaromah M H 2020 The analysis of output based learning implementation in improving students creative and innovative thinking skills in solving h-irregularity Journal of Phys.: Conf. Ser. 1538 012091

[8] Sulistiyono B, Slamin, Dafik, Wangguway Y, and Al Jabbar Z L 2020 students’ creative-innovative thinking skill in solving rainbow antimagic coloring under research based learning model Journal of Phys.: Conf. Ser. 1538 012096

[9] Tohir M, Abidin Z, Dafik, and Hobri 2018 Students creative thinking skills in solving two dimensional arithmetic series through research-based learning Journal of Phys.: Conf. Ser. 1008
[10] Hastuti Y, Dafik, and Hobri 2019 The analysis of student’s combinatorial thinking skill based on their cognitive style under the implementation of research based learning in the total rainbow connection study Journal of Phys.: Conf. Ser. 1211 012088

[11] Wardani P L, Dafik, and Tirta I M 2019 The analysis of research based learning implementation in improving students conjecturing skills in solving local antimagic vertex dynamic coloring Journal of Phys.: Conf. Ser. 1211 012090

[12] 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 Phys.: Conf. Ser. 1211 012109

[13] Waliyati S, Dafik, and Slamin 2019 The analysis of project based learning implementation to improve students creative thinking skill in solving the problem of tiles coloring combination Journal of Phys.: Conf. Ser. 1211 012089

[14] Hayyu A N, Dafik, Tirta I M, Wangguway Y, and Kurniawati S 2020 The analysis of the implementation inquiry based learning to improve student mathematical proving skills in solving dominating metric dimention number Journal of Phys.: Conf. Ser. 1538 012093

[15] Harjito L O, Dafik, Kristiana A I, Maylisa I N, and Wangguway Y 2020 The analysis of problem based learning implementation and its influence to the students generalization thinking skills on solving r-dynamic vertex coloring Journal of Phys.: Conf. Ser. 1538 012092

[16] Karimah M, Dafik, Tirta I M, Wangguway Y, and Al Jabbar Z L 2019 The analysis of the implementation of project based learning and its influence to the student deductive reasoning based on cognitive style on solving super edge local antimagic total labelling Journal of Phys.: Conf. Ser. 1538 012095