On student's metacognition skill in solving division operation under the research-based learning implementation

O A Safiati¹, Dafik², T D Prastiti¹ and Z R Ridlo²

¹Department of Postgraduate Education, Universitas Terbuka, Indonesia
²Department of Math Education Postgraduate, University of Jember, Indonesia
³Department of Science Education, University of Jember, Indonesia

Email: d.dafik@unej.ac.id

Abstract. The HOTS (Higher-order thinking skill) is significantly important, especially in the twenty century. One of the indicators of HOTS is metacognition skill. This skill is related to how students can understand and control their learning styles and mechanisms. However, encouraging the rise of students' metacognition skills is considered to be a challenging task for a teacher. Therefore, this research aims to develop the students' metacognition skills under the implementation of the RBL (Research-Based Learning) model of teaching in solving division problems. This research uses a mixed-method combining a quantitative and qualitative approach in mathematics. The research subjects consisted of a control class of 28 students and an experimental class of 28 students. Data collection techniques utilized tests, questionnaires, observation, and last interviews. The results show that after the implementation of the RBL model of learning, the percentage of students metacognition skills of the control class is classified as follows: very well developed is 7% of the number of students, well developed is 48%, developed 38%, fairly developed is 7%, poorly developed is 0% and very poorly developed is 0%. The experimental class gaining very well developed is 33% of the number of students, well developed is 55%, developed is 10%, fairly developed is 2%, poorly developed is 0% and very poorly developed is 0%. The statistical analysis of the two classes indicates that the inferential t-test shows that the GIS (2-tailed) value is 0.000 (P ≤ 0.05). It implies there is a significant effect of RBL application on the students' metacognition skills. Students under RBL implementation showed their metacognition skills higher than the students without RBL in solving division problems.

1. Introduction
Metacognition skill is essential in nowadays era. Metacognition skill motivates the rise of an autonomous learner in the classroom. Students who have good metacognition skills will know the way of what they are thinking, the manner of what they are doing, the strategy of what they are solving. However, there are still fewer students having good metacognition skills. It implies the student skills in problem solving are very weak, in fact. Problem solving has an important role in mathematics learning. The implementation of problem-solving in mathematics learning can help students to get a pattern for thinking, familiarize their diligence and curiosity, develop the students' smoothness to think, help students make
connection or relation between the material of one with other material, and develop the confidence of students in facing to the unusual situation [15].

The students' success in solving mathematical problems is affected by various factors, among others: concentration, opinions on mathematics, motivation, self-esteem, initial experience, mathematical background, mathematical structure, and confidence [15]. Another factor that also affects the success of mathematics is metacognition [2]. Metacognition skills regard to how well students can manage their learning process, which involves three important skills: (a) planning, which should be passed by selecting the best strategy; (b) Monitoring, which regards a students' awareness of their understanding in solving problems, and (c) evaluation, which is the judgment of their work and learning efficiency[3]. The indicators of metacognition skills is shown in Table 1.

| Factors       | Indicators                                                      |
|---------------|-----------------------------------------------------------------|
| Planning      | • can aware of the given problem,                               |
|               | • can predict the strategic plan,                               |
|               | • can set up the plan to solve the problem,                     |
|               | • can understand the notation to be used;                       |
| Monitoring    | • can utilize the prior knowledge in solving new problems,      |
|               | • able to solve the problem in various ways,                    |
|               | • perform correct working steps,                                |
|               | • check the truth step,                                        |
|               | • able to adjust the results;                                   |
| Evaluation    | • check the advantage and disadvantage of work,                 |
|               | • able to determine the efficiency of differentways,           |
|               | • can apply the method to the problem,                          |

The students' metacognition skills vary for different students, and it will be different when dealing with different problems. In this study, our problem relates to solving the division problem. Students have difficulty in solving division problem since the division concept itself is a bit complicated and there only exist a little technique to solve it. Therefore, in this study, we will apply the RBL to improve the students' metacognition skills in solving division problems. We also, at the same time, explore some new techniques to solve division problems.

RBL model of Teaching in its application uses problem-solving, hands-on and mind-on learning, authentic learning, cooperative learning, contextual learning, and includes the use of the discovery approach [4]. The main objective of implementing RBL is to encourage the presence of higher-order thinking skills in students. Thus the students are able to construct concepts independently of knowledge, and even students must be able to construct some ways to solve a problem related to the given concept. Furthermore, in research-based learning, students actively learn by conducting research on solving certain problems in the classroom. The main achievement of RBL implementation is the novelty of research breakthroughs, even if the results are in the form of initiative solutions, partial solutions, or initial solutions.

The implementation of the RBL model of learning can improve students learning performance in solving two-dimensional arithmetic problems [17]. The research results done by Ridlo recommend that it is very good to implement research-based learning in writing a computer program to improve students' higher-order thinking skills [19]. From the two research results, we can conclude that research-based learning is very important and worthy to be one of the references in improving students thinking skills, and in general, it can improve the students learning outcomes.
The syntax of Research-Based Learning modeled by Arifin [1] describes that there are three main steps, namely: 1. Exposure stage, 2. Experience stage, 3. Capstone Stage. Recently, Dafik (2018) showed a new syntax of Research-Based learning. In this study, we will use the new syntax to solve a division problem [4].

The aim of this study is to analyze the effect of the application of the RBL model on students' metacognition thinking skills. To analyze it, we develop two classes of research. One is an experimental class applied by RBL, and the other is a control class that applied an example and non-example learning model. For the last model, we instructed the class by the following steps, 1) students are divided into several groups, 2) Teachers prepare pictures, 3) students begin to think to solve the problem by analyzing the pictures, 4) through the group discussion, the discussion results are recorded on the paper and read the results for a discussion, and 5) latter, start the comment/discussion on the results, the teacher explained the material respecting to the purpose to be achieved.

In this research, we propose the following research questions: firstly, is there any significant difference in student metacognition thinking skills between the experimental class under the implementation of research-based learning and the control class under the implementation of example and non-example learning in solving division problem. Secondly, to explore the phase portrait of student's metacognition thinking skills under the implementation of research-based learning in solving division problems.

Heruman describes that division is an opponent of multiplication or is also referred to a repetition of subtraction [5]. The main requirement to understand the division concept is that students must have enough illustration either in conceptual or contextual perspectives. Regarding the conceptual perspective, the student has mastered the division concept as a repetition of subtraction? For instance 2 x 3 = 6. In this regards, the teacher can give the question of what \( n \) such that satisfies, \( 2 \times n = 6 \), the student will answer \( n \) is 3 since \( 2 \times 3 = 6 \) in other words, it can be changed into division. Division can be interpreted as repeated reduction, for example, \( 6:2 = 3 \), meaning 6 should be finished divided by 2, i.e. \( 6 - 2 - 2 - 2 = 0 \), the end, how many 2 do we have ?that is the answer. Contextually, we can give an illustration of \( 6:2 \) is for instance, teacher has 6 pieces of bread and two students ask those bread to eat. How many bread does each student get?

2. Research Methods
It is a mixed-method research, and we depict the triangulation quantitative model in Figure 1 [16], and show the experimental design in Table 2.

| Group          | Pre-test | Treatment | Post-test |
|----------------|----------|-----------|-----------|
| B (experimental class) \( n = 28 \) | \( O_1 \) | X | \( O_2 \) |
| A (control class) \( n = 28 \) | \( O_3 \) | - | \( O_4 \) |

2.1 Instruments
The instruments used in this study is a test, observations, questionnaires, and an interview. The pre-test and post-type tests are in an essay type. Observation is done when the learning process is in progress. Observation is done in order to know the learning process clearly and accurately. The questionnaire instruments using the Linkert scale include four categories: agree (4), quite agree (3), not agree (2), and disagree (1).
2.2 Task
The research subjects are encouraged to solve the division problem by using a reminder-like theorem. It is a new technique that involves simple to complex numbers from tens, hundreds, thousands, etc. The technique can be described as follows:

Determine $675 : 5 = \ldots$ and $1476 : 6 = \ldots$

We used to use a "Porogapit" technique to solve the problem. It works as follows:

\[
\begin{array}{c}
135 \\
5 \sqrt{675} \\
\underline{5} \\
17 \\
\underline{12} \\
15 \\
\underline{27} \\
25 \\
\underline{36} \\
25 \\
\underline{246}
\end{array}
\]

\[
\begin{array}{c}
135 \\
6 \sqrt{1476} \\
\underline{12} \\
24 \\
\underline{36} \\
36 \\
\underline{0}
\end{array}
\]

By using a new technique, namely reminder-like theorem, we can reduce the time elapsed, and we get the following:

\[
\begin{array}{c}
675 : 5 \\
\underline{6} \ 17 \ 25 : 5 \\
1 \ 3 \ 5
\end{array}
\]

\[
\begin{array}{c}
1476 : 6 \\
\underline{1} \ 4 \ 27 \ 36 : 6 \\
2 \ 4 \ 6
\end{array}
\]

In general, the technique can be modeled as follows:

\[
\frac{x \ yz \ m}{a \ b \ c} \xrightarrow{\text{reminder } z} \frac{xyz \ m = abc}{m}
\]

Furthermore, after finishing the above task, the students are encouraged to do small research for different numbers and different digits. Students are also asked to determine the division result for a decimal number.

2.3 Data Collection and data analysis
In this case, the two research classes were given a pre-test and post-test. Then, several research subjects were chosen from the experimental class to be interviewed, including observations on activities in both research classes. Furthermore, the t-test was carried out on the pre-test and post-test to determine the significant difference between the experimental class and the control class.
3. Research Findings
Finding a correct measuring tool is important before implementing the research, thus we did a validity test. By using a statistic software the value of $r_{count}$ of each test item are a item_1 is 0.892, item_2 is 0.698, item_3 is 0.698, item_4 is 0.739, item_5 is 0.739. It implies that the values of $r_{count} > r_{table}$. It concludes that the post-test is valid. Furthermore, the overall Cronbach's Alpha Based on Standardized items is 0.812 and $r_{table}$ of a significance level 5% with $dk = N - 1 = 19$, $r_{table} = 0.427$. It implies $r_{count} > r_{table}$. Thus the items are reliable.

Now, we will describe their pre-test results in the statistic descriptive on the students' metacognition skills.
The results above show that both classes have the same variance. The analysis indicates that the metacognition skills of the control class very well-developed are 0%, well-developed is 19%, developed is 31%, fairly developed is 42%, poorly developed is 7% and very poorly developed is 1%, while for the experimental class gaining very well-developed is 0%, well-developed is 20%, developed is 23%, fairly developed is 49%, poorly developed is 6% and very poorly developed is 2%, see Figure 2 and Figure 3. By these results, we conclude that the impact of the implementation RBL model of teaching in improving the students' metacognition skill in solving division problems is significant. Now, we will focus on the two types of tests, namely homogeneity test, and normality test, and at the end is the independent sample t-test analysis.

### Table 3. The SPSS result on the homogeneity Test of Homogeneity of Variances

|        | Levene Statistic | df1 | df2 | Sig. |
|--------|------------------|-----|-----|------|
|        | .352             | 1   | 54  | .555 |

The homogeneity test of the pre-test has the value (Sig.) 0.555 shown in Table 3. This is more than 0.05, it implies the data is homogenous.

### Table 4. The statistical mean analysis of pre-test Descriptive Statistics

|                  | N   | Minimum | Maximum | Mean  | Std. Deviation |
|------------------|-----|---------|---------|-------|----------------|
| Experimentas Class | 28  | 25      | 80      | 55.14 | 13.564         |
| Control Class    | 28  | 31      | 77      | 54.57 | 12.339         |
| Valid N (listwise) | 28  |         |         |       |                |
The mean analysis score of control class is 54.57 (SD = 12.339) and for the experimental class is 55.14 (SD = 13.564) shown in Table 4. The difference is \( t(56) = 0.870, p > 0.05 \), it follows that there is not a significant difference.

**Table 5.** The independent sample t-test analysis result

| Levene's Test for Equality of Variances | t-test for Equality of Means |
|----------------------------------------|------------------------------|
| F           | Sig. | t  | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
| class       |      |    |    |               |                |                       |       |
| Equal variances assumed                  | .352 | .555 | .165 | 54 | .870 | .571 | 3.465 | -6.376 | 7.519 |
| Equal variances not assumed              | .165 | 53.52 | .870 | .571 | 3.465 | -6.377 | 7.520 |

Since the independent sample t-test result of pre-test is 0.870 (p > 0.05), see Table 5, it implies the two classes are homogeneous.

From now on, we deal analysing the post-test. First we test the normality, see Table 6. The results are respectively 0.132 and 0.466 for control and experimental class. They are greater than \( \alpha \) (0.05). Thus the two classes on post-test data are normal function.

**Table 6.** The normality analysis of both classes on post-test

| Tests of Normality | Kolmogorov-Smirnov\(^a\) | Shapiro-Wilk |
|--------------------|--------------------------|--------------|
| Statistic          | df | Sig. | Statistic | df | Sig. |
| Experimental class | .151 | 28 | .099 | .943 | 28 | .132 |
| Control class      | .108 | 28 | .200* | .965 | 28 | .466 |

**Table 7.** The mean analysis on post-test

| Descriptive Statistics | N | Minimum | Maximum | Mean | Std. Deviation |
|------------------------|---|---------|---------|------|----------------|
| Experimental class     | 28 | 57      | 97      | 79.18| 11.298         |
| Control class          | 28 | 48      | 88      | 68.64| 9.867          |
| Valid N (listwise)     | 28 |         |         |      |                |

Table 7 shows the standard deviation of the control class and experimental class. Ther are respectively Mean=68.64, SD = 9.867 and Mean=79.18, SD = 11.298. Furthermore, Table 8 shows that the result of the independent sample t-test of post-test on sig. (2-tailed) is 0.000 (p =< 0.05. It concludes that the implementation of RBL significantly affected the students' metacognition skills in solving the division problem.

**Table 8.** The independent sample t-test analysis on post-test score

| Independent Samples Test | Levene's Test for Equality of Variances | t-test for Equality of Means |
|--------------------------|----------------------------------------|------------------------------|
|                         |                                        | 95% Confidence Interval of the Difference |
|                         |                                        |                               |

7
Now, we will describe their post-test results of their metacognition in the statistic descriptive below.

| Class | Equal variances assumed | Equal variances not assumed |
|-------|-------------------------|----------------------------|
|       | F | Sig. | t | df | Mean Difference | Std. Error Difference | Lower | Upper |
|       | .452 | .504 | 3.72 | 54 | 10.536 | 2.835 | 4.853 | 16.219 |
|       | 3.72 | 53.04 | .000 | 10.536 | 2.835 | 4.850 | 16.221 |

Based on the descriptive statistic of their post-test score, the criteria of their metacognition skills of the control class is very well-developed is 7 %, well-developed is 48%, developed is 38%, fairly developed is 7 %, poorly developed is 0 % and very poorly developed is 0%, while for the experimental class gaining very well developed is 33 %, well developed is 55%, developed is 10%, fairly developed is 2%, poorly developed is 0% and very poorly developed is 0%. Figure 4 and Figure 5 show the comparison. It is seen that the experimental class is better than the control class.

Figure 4. The descriptive statistic of their post-test score of the control class

To complete our result related to student activity, we did an observation activity of all students under the implementation of the RBL model of Teaching. The observation was assessed by using a Linkert scale, which explains student activity that is very active (5), active (4), quite active (3), less active (2), inactive (1). Figure 6 gives the detail.

Figure 5. The descriptive statistic of their post-test score of experiment class
The students involved in the observation was 28 students. Figure 6 tell us that the highest criteria is very active of 48% in the experimental class. It concludes that the application of RBL motivates students to engage actively in solving the division problem, and 36% of students reach the second criteria, the active level, and the rest of 6% are quite active, less active of 6%, and inactive levels of 4%.

Furthermore, as a completion of this study, we observed the students’ worksheet. The followings are the result analysis of student SE_009.

\[
3888 : 8 = 486
\]

Figure 7. The student SE_009 work on the worksheet under the RBL activities

\[
878475 : 2 = 436875
\]

Figure 8. The student SE_024 work on the worksheet under the RBL activities

The analysis of students’ worksheet S_009 determines the different type of the division problem with the previous one. Previously, the students solve the division of tens and hundreds. Now the students are faced with a division of thousands. The main thing, students here are encouraged to solve the problem by using the new techniques described earlier. Students use the generalization of the reminder technique, and they consider should evaluate whether the technique is much easier than "Porogapit" technique. When they have finished solving the division of thousands, namely 3888 : 8, then students are encouraged to solve the divisions related to the thousands in which the initial numbers are smaller than the divisor. Students will start thinking about how 3 can be divided by 8. From the issue, students can determine the way how to divide the number which smaller than the divisor. S_009 did something remarkable. He combines the small number with the number right-behind it. In Figure 7 above, it can be seen that students combine 3 and 8. Thus 38 can be divisible by 8 and follows in the same manner until the result is completed. By doing this problem, it gives the result of division 3888 : 8 = 486.

Furthermore, students S_024 work in the same steps but with different problems as SE_009 students were done. S_024 is encouraged to complete divisions related to hundreds-thousands, and the division process gives a remainder. This case gives a new experience for
students, especially S_024. In Figure 8 above, S_024 completes the solution of the problem. In the same manner, the student starts dividing the first digit by divisor and store the remainder to the following number. Complete the steps, but at the end, the student finds the final reminder. He gets a bit confused about how to store the reminder, but by researcher guidance, the students can do the problem by writing it in a fraction model. Finally, the result of division \(878475: 8 = 125496\frac{3}{7}\).

Based on RBL model of teaching syntax, students go to the third and fourth steps, i.e., students are encouraged to identify the pattern or manner of the obtained result of division and start generalizing the pattern based on the application of the reminder technique to solve the problem of division. Students S_009 and S_024 have found the pattern, and they can generalize division operations for any bigger number. To find out the students' perception about the implementation of RBL model of Teaching, the researcher did an interview on student SE_009. The student is selected due to this student has gained high criteria of metacognition skill. The data obtained through the interview process was transcribed below.

| RBL_Researcher | : After working on this issue, what do you understand? |
| SE_009         | : I understand how to solve the division problem. |
| RBL_Researcher | : Can you obtain how to solve the division problem? |
| SE_009         | : Yes, I tried to solve the division problem by using "Porogapit" and the reminder-like technique. |
| RBL_Researcher | : What do you think? Is it easier to solve the division problem by using the reminder-like technique? |
| SE_009         | : Yes, it is. |
| RBL_Researcher | : Have you already know the steps of solving the division problem by using the reminder-like technique? |
| SE_009         | : Yes, the step is simple and easy. I like it, and it makes it faster to solve the division problem. |
| RBL_Researcher | : Have you ever used such a technique before? |
| SE_009         | : No, I haven't. All the time, I have been using "Porogapit" to solve the division problem when I was in grade 3. |
| RBL_Researcher | : Can you determine the division problem with a different number? |
| SE_009         | : Yes, I can solve the division problem using the reminder technique. |
| RBL_Researcher | : Tell me, how do you start with the technique? |
| SE_009         | : Well, I start to rewrite the number in a bit wider space. |
| RBL_Researcher | : And then, what next? |
| SE_009         | : I draw underline and start to divide number to number from the left side to the right side. |
| RBL_Researcher | : What do you consider then? |
| SE_009         | : Yes, I consider whether the number in a certain digit is divisible by the divisor. |
| RBL_Researcher | : If yes, what do you do, otherwise what do you do? |
| SE_009         | : If yes, I put the result undernet the underline, and if not, I insert the reminder in front of the following number or digit. |
| RBL_Researcher | : What do you deal with the next step? |
| SE_009         | : Yes, again, I consider whether the new number, combination of reminder, and the original number, in a certain digit, is divisible by the divisor. |
| RBL_Researcher | : Do you repeat if it happens? |
By this interview results, we can draw the phase portrait of the student’s metacognition skill in the form of a phase portrait.

**Figure 9.** The student metacognition skill phase portrait of SE_009

Furthermore, from the students' worksheet results, we have found some natural extension of the reminder-like theorem for the numbers 2, 5, and 9. The steps can be described as follows.

1. **438**: 2 = [20][15][40]
   
   2. **2876**: 2 = [10][40][35][30]
   
   3. **75294**: 2 = [35][25][10][45][20]
   
   4. **895738**: 2 = [40][45][25][35][15][40]

* First, multiply the numbers by 5

   1. **3 33**: 9 = 1
   
   2. **4 0 5**: 9 = 1
   
   3. **4 9 2 3**: 9 = 1

* First, multiply the numbers by 2

   1. **3 55**: 5 = [6][10][10]
   
   2. **4 235**: 5 = [8][4][6][10]
   
   3. **8 5370**: 5 = [16][10][6][14][0]
   
   4. **8 9 5 7 3 5**: 5 = [16][18][10][14][6][10]

   5. **8 8 5 6**: 9 = 1
   
   6. **2 3 2 5 6**: 9 = 2
From these results, it shows that students can express different techniques under the implementation of research-based learning by stimulating the reminder-like theorem.

4. Discussion
The findings of this study indicate that the implementation of RBL has a significant affected on the improvement of students’ metacognition skills in solving division. The metacognition skills of the control class are every well-developed is 0 %, well-developed is 48%, developed is 38%, fairly developed is 7 %, poorly developed is 0 % and very poorly developed is 0%, while for the experimental class gaining very well-developed is 33 %, well-developed is 55%, developed is 10%, fairly-developed is 2%, poorly developed is 0% and very poorly developed is 0%. Thus, the student’s metacognition skills in the experimental class showed higher than the control class.

This study was in line with the study conducted by Landine & Steward (1998), showing that doing the real thing in a class will improve the students’ metacognition skills [8]. This also provides that we can improve the student metacognition skills by fostering the students’ activities[8]. The implementation of the RBL model has gain fully involvement of students’ activities [20]. In the RBL, students were challenged to solve a real problem and finally gains a novelty of knowledge [14] and [11]. The highest score of students activities observation gives very active level reached 48%. It proves that during RBL implementation, students are strongly active to solve the problem, and 36% of students reach the active level, and the rest of 6% are quite active, less inactive of 6%, and very inactive levels of 4%.

5. Conclusion
The results showed that the implementation of the Research-Based Learning model has a significant effect on the students’ metacognition skills when students solve the division problems. Therefore, we advise that the implementation of the RBL is very useful in the classroom. However, solving the division problem is considered a difficult problem topic. Thus, the combination of RBL with other learning methods can be studied by further researchers to find a different technique for solving division problems.

Acknowledgment
Foremost, I would like to express my sincere gratitude to the support CEREBEL Research Groups FKIP-University of Jember of the year 2021 for the continuous support of my research paper to pursue a good publication.

References
[1] Arifin, P2010 Research Based Learning. Bandung Institute of Teknologi, Bandung Indonesia
[2] Aurah C, Keakitse S, Isaacs C, andFinci H 2010 The Role of Metacognition in everyday problem solving among primary students in kenya Probl. Educ, 21 9-21.
[3] Dafik, Sucianto B, Irvan M, andRohim M A 2019 The Analysis of Student Metacognition Skill in Solving Rainbow Connection Problem under the implementation of Research-Based Learning International Journal of instruction 12 593-610
[4] Dafik 2018 The Hand Out of the Research-Based Learning Development and the implementation of RBL in FKIP the University of Jember. Jember: Universitas Jember.
[5] Heruman, 2007 The Learning Model of Mathematics for Elementary School. Bandung: Remaja Rosdakarya, Indonesia.
[6] Hobri, Dafik, andHossain A 2018 The implementation of Learning Together in Improving Student’ Mathematical performance. International Journal of instruction 11 483-496.
[7] Kuzle 2013A. Pattern of metacognitive behavior during mathematics problem-solving in a dynamic geometry environment *International Electronic Journal of Mathematics Education* **8** 20-40.

[8] Landine J and Stewart J 1998 Relationship between metacognition, motivation, locus of control, self-efficacy, and academic achievement. *Canadian Journal of Counselling* **32** 200-212.

[9] Monalisa L A, Dafik, Hastuti Y, Hussen S, and Oktavianingtyas E 2019 The implementation of Research-Based Learning in Developing the Students Mathematical Generalization Thinking Skills in Solving a Paving Blocks Design Problem *IOP Conference Series: Earth and Environmental Science* **243** 012168.

[10] Nazula N H, Dafik, and Slamin 2018 The profile of students’ creative thinking skills in solving local antimagic vertex coloring problem in research-based learning *Journal of Physics: Conference Series* **1211** 012109.

[11] Patrick G 2012 Research-Based Learning: Teaching Development Through Field Schools *Journal of Geography in Higher Education* **36** 329-339.

[12] Plomp T and Nieveen N 2013 *Educational Design Research. Enschede the Netherlands* ISBN 978 90 2334 1.

[13] Sabrila A I T P, Dafik, Tirta I M, danMalik R S 2018 Investigation he effect discovery-based learning on student’ metacognition in solving rainbow 2-connection numbers *IOP Conference Series: Earth and Environmental Science* **243** 012053.

[14] Schapper J and Mayson E S 2010 Research-led Teaching: Moving from a fractured engagement to a marriage of convenience *Higher Education Research & Development* **29** 641-651.

[15] Setyadi D 2018 The process of students metacognition in solving mathematical problem *Journal Kreano, Jurnal Matematika kreatif-inovatif* **9** 93-99. 2018.

[16] Sugiono 2016 *The mixed method of research. Alfa-Beta Bandung, Indonesia.* 2016.

[17] Suntusia S, Dafik, and Hobri 2019 The Effectiveness of Research-Based Learning in Improving Students’ Achievement in Solving Two-Dimensional Arithmetic Sequence Problems. *International Journal of Instruction* **12** 17-32.

[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] Z R Ridlo, Dafik, R M Prihandini, C I W Nugroho and R Alfarisi 2019 The effectiveness of research-based learning with computer programming and highly interactive cloud classroom (HIC) elaboration in improving higher order thinking skill in solving a combination of wave functions *Journal of Physics: Conference Series* **1211** 012049.

[20] Z R Ridlo, Dafik, and Nugroho C I W 2020 Report and Recommendation of implementation Research-Based Learning in Improving Combinatorial Thinking Skills embedded in STEM Parachute Design Activities Assisted by CCR (Cloud Classroom), Universal Journal of Educational Research **8** 4 1413-1429.

[21] Z R Ridlo, Dafik and C I W Nugroho 2020 The effectiveness of implementation research-based learning model of Teaching integrated with Cloud Classroom (CCR) to improving critical thinking skills in an astronomy course *Journal of Physics: Conference Series* **1563**012034.