The Development of Research-Based Learning Tools with a STEM Approach to Improve Metaliteracy Skills to Solve Rainbow Vertex Anti-magic Coloring Problems

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ABSTRACT

Metaliteracy is the framing and strengthening of information literacy based on critical and creative thinking. Metaliteracy indicators include generating, combining, using, participating, sharing, and collaborating. To implement higher-order thinking skills, we implement research-based learning with a STEM approach. To develop the students’ metaliteracy, educators should also equip the learning process by learning materials. In this study, we developed RBL-STEM learning materials to improve students’ metaliteracy skills. The learning materials that have been developed are considered to be valid, effective, and practical. The validity score obtained in each materials is 3.5 for the Lesson Plan, 3.54 for the Student Worksheet, and 3.63 for the Learning Outcomes Test.

INTRODUCTION

Metaliteracy skills are one of the skills that can be applied in society in order to create a society that can process information and apply it in everyday life. The application of this metaliteracy skill can be started by applying it at the college level. The indicators of metaliteracy consist of producing, combining, using, participating, sharing, and collaborating. In comparison, the level of metaliteracy is divided into low, medium, and high levels. Students are classified at a high level if they can fulfill all indicators of metaliteracy thinking; classified at a medium level, students can fulfill 3 to
4 indicators of metaliteracy thinking, and at a low level, students can fulfill 2 to 1 indicator of metaliteracy thinking.

One of the learning models that is often used in applying this metaliteracy is Research-Based Learning (RBL). Dafik (in Suntusia et al., 2019) explained that RBL is a learning method that involves contextual learning, authentic learning, problem-solving, cooperative learning, and inquiry discovery approaches.

STEM was introduced by the NSF (National Science Foundation) of the United States in 1990, which stands for Science, Technology, Engineering, and Mathematics (Fathoni et al., 2020). STEM education combines several fields of science, namely Science, Technology, Engineering, and Mathematics, in the concept of implementing learning.

Mathematics studies many things, one of which is graph theory. Graph theory was first introduced in 1736 by a Swiss mathematician named Leonhard Euler. He used graph theory to solve the Konigsberg bridge problem. A graph is a discrete structure consisting of a set of objects called vertices and edges that connect existing vertices (Adiwijaya in Apriyanto, 2018). Many topics are studied in graph theory, including rainbow vertex anti-magic coloring. Suppose \( f : E(G) \to 1,2,3,\ldots, |E(G)| \) is labeling of a graph G. The function f is called rainbow vertex anti-magic coloring if for any two vertices u and v, all internal vertices on the path u - v have different weights. The vertex weight is denoted by \( \omega(u) \) for each \( u \in V(G) \) where \( \omega(u) = \sum_{uu' \in E(G)} f(uu') \).

Problems in graph theory, especially in the rainbow vertex anti-magic coloring problem, in solving them require quite complete skills, namely by applying the internet of things. There are six indicators in metaliteracy, namely Produce, Incorporate, Use, Share, and Collaborate.

**RESEARCH METHOD**
The stages used in this study refer to the development of Thiagarajan's 4D-Model, which consists of the defining stage, the design stage, the development stage, and the dissemination stage.
RESULTS AND DISCUSSION

STEM Components

This study uses a research-based learning model with a STEM approach to enable students to learn and develop knowledge and skills in Science, Technology, Engineering, and Mathematics. The explanation of STEM is as follows: (1) Science, students are expected to understand the problems presented regarding the placement of sediment control buildings and determining rivers that have the potential to flood and those that do not; (2) Technology, students are expected to use the internet to find understanding and solutions to the problems provided. In addition, students can search and study the latest studies on the topic of rainbow vertex anti-magic coloring; (3) In Engineering, students are expected to be able to develop the topic of rainbow vertex anti-magic coloring in several graphs and be able to solve problems regarding sediment control buildings that will be built in a river flow; and (4) Mathematics, students can apply the concept of rainbow vertex anti-magic coloring in several graphs and the
formation of a graph of a water flow, starting from labeling the edges of the graph and calculating the point weight of each point in the graph.

In summary, it can be explained as follows.

Sediment control buildings are buildings that function to reduce flow velocity and deposit sediment over a certain period (elearning.litbang.pu.go.id). This sediment control building should have different sizes in a river flow to minimize flooding. In this case, it can use the concept of rainbow vertex anti-magic coloring.

The stages of device development consist of defining, designing, developing, and disseminating. The define stage begins with a preliminary-late analysis in which rainbow vertex anti-magic coloring was chosen as the topic of study because this topic belongs to a new topic that combines two topics, namely rainbow dot coloring and anti-semitic labeling. Solving this problem requires students who are active and creative so that they can find the expected coloring patterns. A learning model is suitable for research-based learning to train students’ meal iteration skills. They are followed by student analysis which aims to obtain data on the characteristics of students of S1 Mathematics Education, FKIP, University of Jember. Furthermore, a concept analysis was carried out, and a concept map was obtained in Figure 1. Then it ends with an analysis of the task to identify the student's metaliteracy skills following the expected final ability.

**Figure 3.1** Rainbow Vertex Anti magic Coloring Concept Map
The steps in this stage are preparing tests and instruments, media selection, format selection, and initial design. The first learning device is the Lesson Plan; this Lesson Plan is prepared on the topic of rainbow vertex anti-magic coloring, and a research-based learning model with a STEM approach. The second learning tool produced is the Student Worksheet. This student worksheet contains STEM problems, namely flood problems, by determining river flows that have the potential to flood and those that do not have the potential to flood using graph artificial neural networks. In addition, it also determines the size of sediment control buildings using the concept of rainbow vertex anti-magic coloring.

![Figure 2 Student Worksheet Design](image)

The third learning tool is the Learning Outcome Test, where the results of this test are used to measure students' metaliteracy skills. Pre-test and post-test are done individually.

![Figure 3 Learning Outcomes Test Design](image)

The third stage of device development is development. At the development stage, all developed devices were validated by validators. The devices were validated by two validators, lecturers of the Mathematics Education study program, FKIP, University of Jember, namely Ridho Alfarisi, S.Pd., M.Si., and Lela Nur Safrida, S.Pd., M.Pd. In general, based on the assessment of the two validators, all learning tools in the form of Lesson Plan, Student Worksheet, and Learning Outcome Test can be used with minor revisions.
Format, Content, and Language Validation

A device is said to be valid if it meets a score of $3,25 \leq V_a < 4$. The validation results of the Student Assignment Design can be seen in Table 3.1. Based on Table 1, a score of $V_a = 3,5$ was obtained so that the Student Assignment Design can be said to be valid.

Table 1 Results of validation of Lesson Plan

| No | Assessed Aspect                                           | Validator | Average | Percentage |
|----|----------------------------------------------------------|-----------|---------|------------|
|    |                                                          | 1         | 2       |            |
| I. | Format                                                  |           |         |            |
|    | 1. Clarify of course outcomes (CPMK)                     | 4         | 3       | 3,5        | 87,5%     |
|    | 2. Clarify of expected end abilities (SUB-CPMK)          | 3         | 4       | 3,5        | 87,5%     |
| II. | Content                                                |           |         |            |
|    | 1. Lesson plan is presented systematically               | 4         | 4       | 4          | 100%      |
|    | 2. The suitability of the task description with the anti-magic rainbow side coloring material | 3         | 4       | 3,5        | 87,5%     |
| III. | Language and Writing                                  |           |         |            |
|     | 1. Using language that is in accordance with correct Indonesian Language Rules (EYD) | 3         | 3       | 3          | 75%       |
|     | 2. The language used is easy to understand               | 3         | 4       | 3,5        | 87,5%     |
|     | **Total score of all aspects**                          |           |         | **21**     |
|     | **Average score of all aspects**                        |           |         | **3,5**    | **87,5%** |

The results of the validation of the Student Worksheet can be seen in Table 3.2. Based on Table 1, the score is obtained, $V_a = 3,54$. So that the Student Worksheet can be said to be valid.

Table 2 Results of Student Worksheet Validation

| No | Assessed Aspect                                           | Validator | Average | Percentage |
|----|----------------------------------------------------------|-----------|---------|------------|
|    |                                                          | 1         | 2       |            |
| I. | Format                                                  |           |         |            |
|    | 1. Student worksheet have clear work instructions.       | 3         | 4       | 3,5        | 87,5%     |
|    | 2. The Systematics of the student worksheet is clearly written | 3         | 4       | 3,5        | 87,5%     |
|    | 3. Interesting presentation of the student worksheet     | 3         | 4       | 3,5        | 87,5%     |
| II. | Content                                                |           |         |            |
|    | 1. The material is presented in accordance with the learning objectives, CPL, CPMK, and Sub CPMK | 4         | 4       | 4          | 100%      |
|    | 2. Correctness of concept of material                    | 4         | 3       | 3,5        | 87,5%     |
|    | 3. Problems raised according to indicators of metaliteracy skills and STEM-based. | 3         | 4       | 3,5        | 87,5%     |
|    | 4. Each activity uses the RBL stages                     | 4         | 4       | 4          | 100%      |
|    | 5. The activities presented can be used to               | 2         | 4       | 3          | 75%       |
analyze students metaliteracy.

### III. Language and Writing

1. Using language that is in accordance with correct Indonesian Language Rules (EYD)  
   | No | Assessed Aspect                                | Validator | Average | Percentage |
   |----|-----------------------------------------------|-----------|---------|------------|
   | 1  | Using language that is in accordance with     | 3         | 4       | 3.5        | 87.5%      |
   |    | correct Indonesian Language Rules (EYD)       |           |         |            |            |

2. The language used is easy to understand and does not cause multiple interpretations  
   | No | Assessed Aspect                                | Validator | Average | Percentage |
   |----|-----------------------------------------------|-----------|---------|------------|
   | 1  | The language used is easy to understand and   | 4         | 4       | 4          | 100%       |
   |    | does not cause multiple interpretations        |           |         |            |            |

3. The language used is communicative  
   | No | Assessed Aspect                                | Validator | Average | Percentage |
   |----|-----------------------------------------------|-----------|---------|------------|
   | 1  | The language used is communicative             | 3         | 3       | 3          | 75%        |

**Total score of all aspects** 39  
**Average score of all aspects** 3.54  
**88.5%**

Validation Result of Learning outcomes can be seen in Table 3.3. Based on Table 1, the score show $V_a = 3.63$. So that the Learning Outcomes Test Sheet can be said to be valid.

### Table 3 Validation Result of Learning outcomes

| No | Assessed Aspect                                | Validator | Mean | Presentation |
|----|-----------------------------------------------|-----------|------|--------------|
| 1  | Clarity of test work instructions             | 4         | 4    | 4            | 100%       |
| 2  | Interesting learning outcomes presentation    | 3         | 4    | 3.5          | 87.5%      |

### I. Format

1. Clarity of test work instructions  
   | No | Assessed Aspect                                | Validator | Mean | Presentation |
   |----|-----------------------------------------------|-----------|------|--------------|
   | 1  | Clarity of test work instructions             | 4         | 4    | 4            | 100%       |

### II. Content

1. The material presented is in accordance with CPL, CPMK, Sub CPMK, and learning objectives  
   | No | Assessed Aspect                                | Validator | Mean | Presentation |
   |----|-----------------------------------------------|-----------|------|--------------|
   | 1  | The material presented is in accordance with  | 4         | 4    | 4            | 100%       |
   |    | CPL, CPMK, Sub CPMK, and learning objectives  |           |      |              |            |

2. The suitability of the test questions with the Antiajaib Rainbow Side Coloring material  
   | No | Assessed Aspect                                | Validator | Mean | Presentation |
   |----|-----------------------------------------------|-----------|------|--------------|
   | 1  | The suitability of the test questions with    | 4         | 4    | 4            | 100%       |
   |    | the Antiajaib Rainbow Side Coloring material |           |      |              |            |

3. Issues raised according to metaliteracy and STEM-based skills indicators  
   | No | Assessed Aspect                                | Validator | Mean | Presentation |
   |----|-----------------------------------------------|-----------|------|--------------|
   | 1  | Issues raised according to metaliteracy and   | 4         | 4    | 4            | 100%       |
   |    | STEM-based skills indicators                  |           |      |              |            |

4. Learning outcomes is arranged according to the stages of the RBL  
   | No | Assessed Aspect                                | Validator | Mean | Presentation |
   |----|-----------------------------------------------|-----------|------|--------------|
   | 1  | Learning outcomes is arranged according to    | 4         | 4    | 4            | 100%       |
   |    | the stages of the RBL                         |           |      |              |            |

5. The difficulty of the test questions is in accordance with the ability of the students  
   | No | Assessed Aspect                                | Validator | Mean | Presentation |
   |----|-----------------------------------------------|-----------|------|--------------|
   | 1  | The difficulty of the test questions is in    | 3         | 3    | 3            | 75%        |
   |    | accordance with the ability of the students   |           |      |              |            |

6. The number of questions and the level of difficulty according to the allocation of time given  
   | No | Assessed Aspect                                | Validator | Mean | Presentation |
   |----|-----------------------------------------------|-----------|------|--------------|
   | 1  | The number of questions and the level of      | 3         | 3    | 3            | 75%        |
   |    | difficulty according to the allocation of     |           |      |              |            |
   |    | time given                                    |           |      |              |            |

7. The problem of the test questions can measure the metaliteracy thinking skills of students  
   | No | Assessed Aspect                                | Validator | Mean | Presentation |
   |----|-----------------------------------------------|-----------|------|--------------|
   | 1  | The problem of the test questions can         | 3         | 4    | 3.5          | 87.5%      |
   |    | measure the metaliteracy thinking skills of   |           |      |              |            |
   |    | students                                      |           |      |              |            |

### III. Language and Writing

1. The problem is formulated in simple  
   | No | Assessed Aspect                                | Validator | Mean | Presentation |
   |----|-----------------------------------------------|-----------|------|--------------|
   | 1  | The problem is formulated in simple           | 3         | 4    | 3.5          | 87.5%      |
Practically Test

The practicality test of this learning tool is carried out by analyzing student learning activities and lecturer activities during learning. Observations of learning activities in the classroom were carried out by five observers taken from Master of Mathematics Education students, the average overall score of the observation results was 3.89 and the percentage was 97.25%. Meanwhile, based on the criteria for the quality of learning devices, a device is said to be practical if the observation results are good (80% ≤ score < 90%) or very good (90% ≤ score ≤ 100%). So, it can be concluded that the device developed on the basis of the results of observations meets the criteria very well. In detail, the average score obtained is as Table 3.4.

Table 3 Observation Results of Device Practicality Test

| No | Assessed Aspect                                                                 | Validator | Mean | Presentation % |
|----|---------------------------------------------------------------------------------|-----------|------|----------------|
|    | I. FORMAT                                                                        |           |      |                |
| 1  | The format makes it easy for observers to fill in                               | 4         | 4    | 100%           |
| 2  | Observation sheet has complete component                                        | 3.8       | 95%  |                |
|    | II. LANGUAGE                                                                     |           |      |                |
| 1  | Compatibility with EYD                                                          | 4         | 100% |                |
| 2  | The language used is communicative                                               | 4         | 100% |                |
| 3  | The language used is unambiguous                                                 | 4         | 100% |                |
| 4  | Clarity of instructions and directions                                           | 4         | 100% |                |
|    | III. CONTENT                                                                     |           |      |                |
| 1  | Conformity with the student assignment design                                    | 3.4       | 85%  |                |
| 2  | Conformity of the order of observation with the student assignment design        | 4         | 100% |                |
| 3  | Statements are formulated clearly, specifically, and operationally so that they are easy to measure | 3.8 | 95% |                |

Average of the overall score of the observation results 3.89
The overall average percentage of the observational score 97.25%

Effectiveness Test

The effectiveness of the developed device is seen from the completeness of the student learning outcomes test. The results of the answers collected by students were obtained by a total of 19 students getting a score above 60, this means that 86% of students are complete. Based on the interval of the student mastery determination score, if ≥ 80% of
the total number of students has been completed, it has been completed classically. Furthermore, an analysis of student activities was carried out, based on student activity analysis data, a percentage of student activity was obtained, namely 95.5%. Based on the criteria for data from student activity observations, students meet the criteria of being very active if the percentage obtained is $90\% \leq a < 100\%$. It can be concluded that students meet the criteria of being very active. The results of the recapitulation of student response scores are displayed in Table 3.5.

Table 4 Observation Results of Student Activity

| No | Assessed Aspect                                                                 | Mean | Presentation |
|----|--------------------------------------------------------------------------------|------|--------------|
|    | **I. Syntax**                                                                    |      |              |
| 1. | The level of implementation of the entire learning stage is                      | 3.8  | 95%          |
| 2. | The implementation of the sequence of learning activities reflects research-based learning oriented metaliteracy skills | 3.8  | 95%          |
|    | **II. Social System**                                                           |      |              |
| 1. | The desired level of implementation of the situation (atmosphere) (group formation, discussion, questioning, arguing, submitting opinions, respecting each other at work) | 4    | 100%         |
| 2. | The level of interaction in learning (between students, and between students-lecturers) | 3.6  | 90%          |
| 3. | The implementation of lecturer behavior realizes the principles and concepts of metaliteracy in research-based learning | 3.6  | 90%          |
|    | **III. Principle of reaction and Management**                                    |      |              |
| 1. | The teacher's ability to accommodate and provide opportunities for students to ask questions, express opinions, and respond | 4    | 100%         |
| 2. | The level of implementation of the behavior of lecturers providing assistance, guidance, guiding students in learning | 3.8  | 95%          |
| 3. | The level of implementation of lecturer behavior gives motivation in learning     | 3.8  | 95%          |
| 4. | The level of implementation of lecturer behavior involves students actively in learning | 3.8  | 95%          |
| 5. | The level of implementation of lecturers facilitates students to learn           | 4    | 100%         |

Average overall score 3.82
Average percentage of overall score 95.5%

Then an analysis of the results of student responses was carried out, the results of the analysis showed that in the learning atmosphere items showed the lowest positive response, it is 81.8%. This is because the research was carried out online, using zoom meeting media. Furthermore, the highest positive response was found in the novelty item of the student worksheet device, this is because the topics discussed in the student
worksheet are indeed relatively new to students. The results of the recapitulation of student response scores are displayed in Table 6.

**Table 5 Recapitulation Results of Student Response**

| No | Assessed Aspect | Number of answers | Presentation of |  |
|----|-----------------|-------------------|-----------------|--|
| 1. | Do you feel good about the following learning components? |  |  |
|    | Learning materials | 19 | 3 | 86,4% | 13,4% |
|    | Student worksheet | 21 | 1 | 95,5% | 4,5% |
|    | Learning atmosphere | 18 | 4 | 81,8% | 18,2% |
|    | Teaching method | 20 | 2 | 90,9% | 9,1% |

Are the following learning components new?

| 2. | Learning materials | 20 | 2 | 90,9% | 9,1% |
|    | Student worksheet | 22 | 0 | 100% | 0% |
|    | Learning atmosphere | 19 | 3 | 86,4% | 13,4% |
|    | Teaching method | 21 | 1 | 95,5% | 4,5% |

Are you interested in participating in this lesson?

| 3. |  | 20 | 2 | 90,9% | 9,1% |

Whether you can clearly understand the language used on:

| 4. | Student worksheet | 20 | 2 | 90,9% | 9,1% |
|    | Metaliteracy skills test question | 21 | 1 | 95,5% | 4,5% |

Are you able to understand the meaning of each

| 5. | Student worksheet | 19 | 3 | 86,4% | 13,4% |
|    | Metaliteracy skills test question | 20 | 2 | 90,9% | 9,1% |

Are you interested in the appearance (writing, drawing, and location of the image) on?

| 6. | Student worksheet | 21 | 1 | 95,5% | 4,5% |
|    | Metaliteracy skills test question | 21 | 1 | 95,5% | 4,5% |

Based on the above criteria, it can be concluded that the learning tools developed can be classified as effective devices.

**Data Analysis**

**Normality Test**

Before the paired sample T test was held. The resulting data should be normal. Based on Table 7, the p.value is 0.10 > 0.05. So, it can be concluded that this data is normally distributed.

**Table 6 Normality Test**

| Statistic | p. value | Method | Data. Name |
|-----------|----------|--------|------------|
| 0,96 | 0,10 | Shapiro-Wilk normality test | datasetInput()[, input$var.y] |
| 0,96 | 0,10 | Shapiro-Wilk normality test | datasetInput()[, input$var.y] |

**Uji paired sample T test**

**Table 7 Paired Samples Statistics**

| Mean | N | Std. Deviation | Std. Error Mean |
In Table 8, it is explained that the mean for pre-test is 43.27 and for post-test is 76.81. Because the average score of pre-test and post-test results is 43.27 (pre-test) < 76.81 (post test). This means that descriptively there is a difference in the average learning outcomes between pre-test and post-test.

**Table 8 Paired Samples Correlations**

|                | N | Correlation | Sig. |
|----------------|---|-------------|------|
| Pair 1 Pre Test & Post Test | 26 | .290 | .151 |

Based on the output in Table 9, it is known that the value of the correlation coefficient is 0.290 and the significance value (Sig.) is 0.151. Because of the sig value, 0.151 > 0.05. Then it can be concluded that there is no relationship between the pre-test variable and the post-test variable.

**Table 9 Paired Samples Test**

|                | Mean | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference Mean | t  | df | Sig. (2-tailed) |
|----------------|------|----------------|-----------------|-----------------------------------------------|----|----|----------------|
| Pair 1 Pre Test - Post Test | 33.53 | 11.236 | 2.204 | -38.077, -29.000 | -15.21 | 25 | .000 |

**DISCUSSION**

Research-based learning tools with a developed STEM approach must meet valid, practical, and effective criteria. The device that has been developed is carried out a validation process by two validators, namely two lecturers from mathematics education FKIP Jember University. The validation results show that this learning device is included in the valid category, this is in line with Margiandini’s explanation which shows that a learning device is said to be valid if it meets $61 < score < 80$ and is very valid if it meets $81 < score < 100$ (Margiandini, et al. 2022). In addition, these learning tools have also met the criteria for learning tools to be called practical and effective.

This research-based learning model is recommended in the implementation of education in order to produce higher student motivation and can improve learning outcomes and be able to apply it in life (Dafik, 2019). This research-based learning if applied in the classroom will result in students being more active, creative, and able to think more critically than students who use conventional learning. This is in accordance with research conducted by Suntusia (2019), Suntusia explained that learning carried out in conventional classes causes students to tend to be passive and lack the impetus to develop their potential (Suntusia, 2019).

**CONCLUSION**
The device that has been developed has been validated by two validators and tested on a trial class. The results of this validation meet the criteria of validity, practicality, and effectiveness. The validity score obtained in each device is 3.5 for the Lesson Plan (valid), 3.54 for Student Worksheet (valid), and 3.63 for learning outcomes (valid). The observation score for the implementation of learning resulted in 3.89 with a percentage of 97.25%. In addition to being valid and practical, the device also meets the criteria of effectiveness. On average, 91% of students in this trial class are classified as complete students and the response from students is positive. Based on the test results, researchers got 19 students who got scores above 60. This means that 86.7% of students in this class have completed and met one of the effectiveness criteria. The student response questionnaire also gave more positive responses than negative responses.

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REFERENCE
Budi, H.S., Dafik, and I M Tirta. 2021. On the implementation of project-based learning to improve the students creative thinking skills in solving rainbow antimagic coloring problems. *Journal of Physics: Conference Series*, 1836, p.1-16.

Dafik, Sucianto B, Ivran M, 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 No 4 e-ISSN: 1308-1470.

Figueroa, F E., D Vanneste, B A Vanegas, K F Pacheco, and S R Giron. 2021. Research-based learning (RBL): Added-value in tourism education. *Journal of Hospitality, Leisure, Sport & Tourism Education*, 28, p.1-10.

Forawi, S. 2018. Science, Technology, Engineering and Mathematics (STEM) Education: Meaningful Learning Contexts and Frameworks. *International Conference on Computer, Control, Electrical, and Electronics Engineering*. p.1-4.

Hakim, R A., Dafik, and I M Tirta. (2021). The study of the implementation of research-based learning model to improve the students’ proving skills in dealing with the resolving efficient dominating set problem. *Journal of Physics: Conference Series*, 1836, p.1-15.

He, X. Tingting Li, Ofir Turel, Yong Kuang, Hui Zhao, Qinghua He. 2021. The Impact of STEM Education on Mathematical Development in Children Aged 5-6 Years. *International Journal of Educational Research*, 109, p.1-13.

Kumar, C S H., and N Parvathi. (2017). Rainbow Vertex Coloring for Central and Total Graph of Star Graph. *International Journal of Pure and Applied Mathematics*, 114(1), p.17-27.
Kurniawati, E.Y., Dafik, I H Agustin, and I N Maylisa. (2022). The analysis of students metaliteracy under the implementation of RBL-STEM in solving graph rainbow antimagic coloring problems. *Journal of Physics: Conference Series*, 2157, p.1-14.

Margiandini, J., Suratno, and Suparti. (2022). The Development of Illustrated Science Student Worksheets with Scientific Approach to Improve Questioning Skills and Learning Outcomes of Elementary Students Regarding Weather Theme and Its Effect on Humans. *Pancaran Pendidikan*, 11(1), p.57-72.

Marsidi, I H Agustin, Dafik, and E Y Kurniawati. (2021). On Rainbow Vertex Antimagic Coloring of Graphs: A New Notion. *CAUCHY*, 7(1), p.64-72.

Marsidi, I H Agustin, Dafik, and E Y Kurniawati, and R Nisviasari. (2022). The rainbow vertex antimagic coloring of tree graphs. *Journal of Physics: Conference Series*, 2157, p.1-8.

Mazidah, T., Dafik, and Slamin. (2021). On the student’s combinatorial thinking skills under the implementation of research based learning in solving resolving independent domination number of graphs. *Journal of Physics: Conference Series*, 1836, p.1-15.

Safari, O. A., Dafik, T. D. Prastiti, and Z R Ridlo. (2021). On student's metacognition skill in solving division operation under the research-based learning implementation. *IOP Conf. Series: Earth and Environmental Science*, 747, p.1-13.

Suntusia, 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(1), p.17-32.

Wang, T M. and G H Zhang. (2013). On antimagic labeling of regular graphs with particular factors. *Journal of Discrete Algorithms*, 23, p.76-82.
