International Journal of Current Science Research and Review
ISSN: 2581-8341
Volume 06 Issue 01 January 2023
DOI: 10.47191/ijcsrr/V6-i1-22, Impact Factor: 5.995
IJCSRR @ 2023
www.ijcsrr.org

# RBL-STEM Learning Activity Framework: The Development of Paving Block Decorations Using Local Antimagic Coloring Techniques in Improving Students' Conjecturing Thinking Skills

**Yessi Alpian[1], Tita Khalis Maryati[1], Kadir[1], Dafik[2,3], Ika Hesti Agustin[3,4]**
[1] Department of Mathematics Education, UIN Syarif Hidayatullah, Jakarta, Indonesia
[2] Department of Math Education Postgraduate, Universitas Jember, Jember, Indonesia
[3] PUI-PT Combinatorics and Graph, CGANT, Universitas Jember, Jember, Indonesia
[4] Department of Mathematics, Universitas Jember, Jember, Indonesia

**ABSTRACT:** The ability of conjecturing thinking skill is very important in the industrial era 4.0. Conjecturing thinking skills are the skills to make strong guesses or predictions on problem solving. This skill is also strongly related to the skill of generalizing from a specific truth to a broad truth. Therefore in this study, the Research-Based Learning model which is integrated with the STEM approach (Science, Technology, Engineering, Mathematics) will be applied to solve the STEM problem of paving block decorations. Students are introduced to the application in the form of local antimagic coloring techniques. The next step is how to bring STEM problem solving in learning class, then the developed RBL and STEM tools in learning to improve students' conjecturing thinking skill. Base on this study, it shows that the problem solving elaborated with four elements of STEM is considered to be a breakthrough in applying RBL-STEM in the classroom to solve the paving block decoration problem.

**KEYWORDS:** Conjecturing thinking skill, Local antimagic coloring, Paving block decorations**,** Research-Based Learning, STEM

## INTRODUCTION

Conjecturing thinking skills are the skills to make strong guesses or predictions that there will be truth. This skill is also strongly related to the skill of generalizing from a specific truth to a broad truth. Through this skill students can expand the truth by notice the structured archetype so that it is expanded with a widespread pattern. Specifically, the term of conjecture in mathematics is a statement that cannot be proven mathematically, but it has empirical evidences in the form of cases and examples [1].

The conjecturing process according to [2] is a mental activity in building conjectures based on our knowledge. This activity can be see when students solve the problems. Some experts such as [3] argue that conjecture is a statement that seems plausible but it truth can't be ascertained by the solver. So that the truth be ascertained because there is no counter-example (antidote to the theory). In addition, [4] infer that conjecture is an empirical fact that has not been validated for its veracity. There are seven indicators of conjecture thinking ability, viz: (1) observing cases; (2) organizing cases; (3) finding and predicting patterns; (4) formulate conjectures; (5) validate the conjecture; (6) generalize the conjecture; and (7) approve (substantiate,vindicate) the conjecture [1,4].

One of learning model alternative that can be used to improve conjecturing thinking skills is a research-based learning model. This learning model provides an opportunity for students to do research or study. In addition, this learning model is also able to improve students' thinking ability. Dafik, et al. [5] argues that a research-based learning model is a teaching model that involves students in developing critical thinking and problem-solving skills by acquiring knowledge and concepts from learning. This opinion is strengthened by Lockwood in research [6] which states that research-based learning models generate knowledge with the following stages, viz: formulating hypotheses, collecting data to be used, analyzing the data that has been obtained, making conclusions, then compiling reports.

Research-based learning models have been widely researched by other researchers including, [7] applying the research-based learning model to analyze students' metaliteration ability, Ridlo, et al. [8] applying a research-based learning model to analyze students' combinatorial thinking ability, and Dafik, et al. [9] applying the research-based learning model to analyze students' metacognition ability. The main characteristic of implementing a research-based learning model is the availability of RG (Research Group). RG is a group of researchers who work on teaching, research, community service activities, and supervise specialized

International Journal of Current Science Research and Review
ISSN: 2581-8341
Volume 06 Issue 01 January 2023
DOI: 10.47191/ijcsrr/V6-i1-22, Impact Factor: 5.995
IJCSRR @ 2023
www.ijcsrr.org

research that interest to solve basic problems whether it's from simple to complex problems [10]. The availability of this research group is one of the important factors in the research-based learning model because members must be involved and cooperate in do the research [9]. After the research group is formed, the next stage is applying the research-based learning model. Several researchers have studied the implementation of research-based learning in [1,7-10] describe the stages of research-based learning in Figure 1.

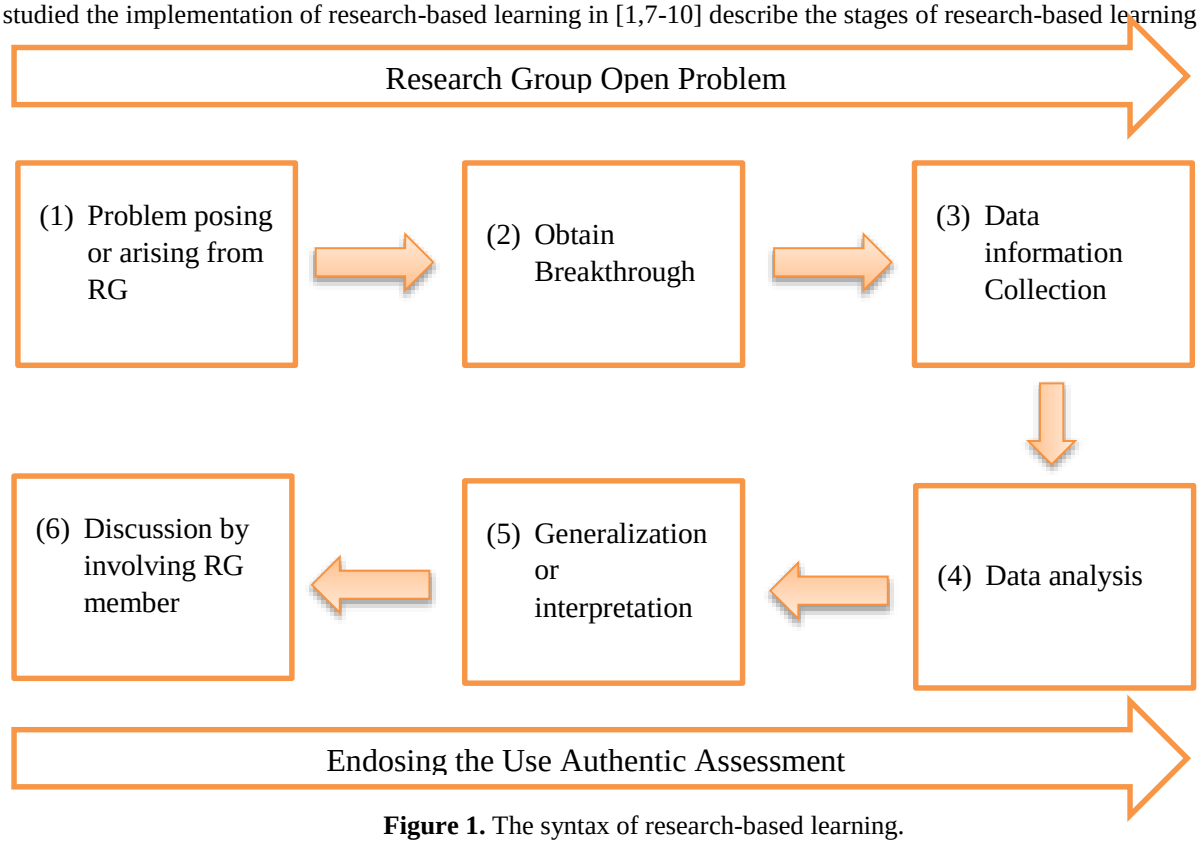



**Figure 1.** The syntax of research-based learning.

Kristiana, et al. [7] emphasized that research-based learning models require contextual and realistic problems and include at least four aspects of scientific studies including science, technology, engineering and mathematics or known as STEM.

Not a few researchers have applied research-based learning models by integrating STEM approaches including research conducted by [5,7,8]. By applying the STEM approach in learning, students are expected to be able to solve problems in everyday life using aspects of science, technology, engineering and mathematics so that they (student) can sharpen their cognitive and affective abilities [11].

Based on the description above, further research is needed in applying research-based learning models with a STEM approach to improve students' conjecture thinking skills. One of researcher who has conducted this research, namely [5]. The research focused on the problem of dyeing r-dynamic knots, but in this study focused on the problem of paving block decoration using local antimagic staining techniques. Nazula, et al. [12] in their research explained that local antimagic staining is a graph that labeled on its side so that the weight of the point (the sum of all side labels that connected to a point) is different for the two points.

## RESEARCH METHODS

This type of research is a narrative qualitative method. This research started from collecting some literature to be review related to RBL and STEM. This includes exploration related to STEM problems. Then developed the syntactic framework for RBL-STEM integration in solving these STEM problems. Furthermore, learning outcomes and objectives will also be presented, and then include the development of indicators and sub-indicators related to conjecturing. Then the research continued by outlining the role of the four STEM elements in solving the problems above. Only then the last thing to do is to describe each stage of the RBL complete

International Journal of Current Science Research and Review
ISSN: 2581-8341
Volume 06 Issue 01 January 2023
DOI: 10.47191/ijcsrr/V6-i1-22, Impact Factor: 5.995
IJCSRR @ 2023
www.ijcsrr.org

with learning activities, and the very last is to complete the indicators and sub-indicators of conjecture including in it is to show the assessment instrument.

## RESEARCH RESULTS

### Syntax of Research-Based Learning with a STEM Approach

The following will be presented a syntax or framework for applying the RBL-STEM model in improving students' conjecture thinking skills in solving paving block decoration problems with using local antimagic coloring techniques. The framework aims to combine a research-based learning model with a STEM approach to improve conjecture skills in solving paving block decoration problems by using local antimagic coloring techniques. In the early stages of a research-based learning framework, it raises problems that arises from research groups in the form of open problems. As for the problems caused:

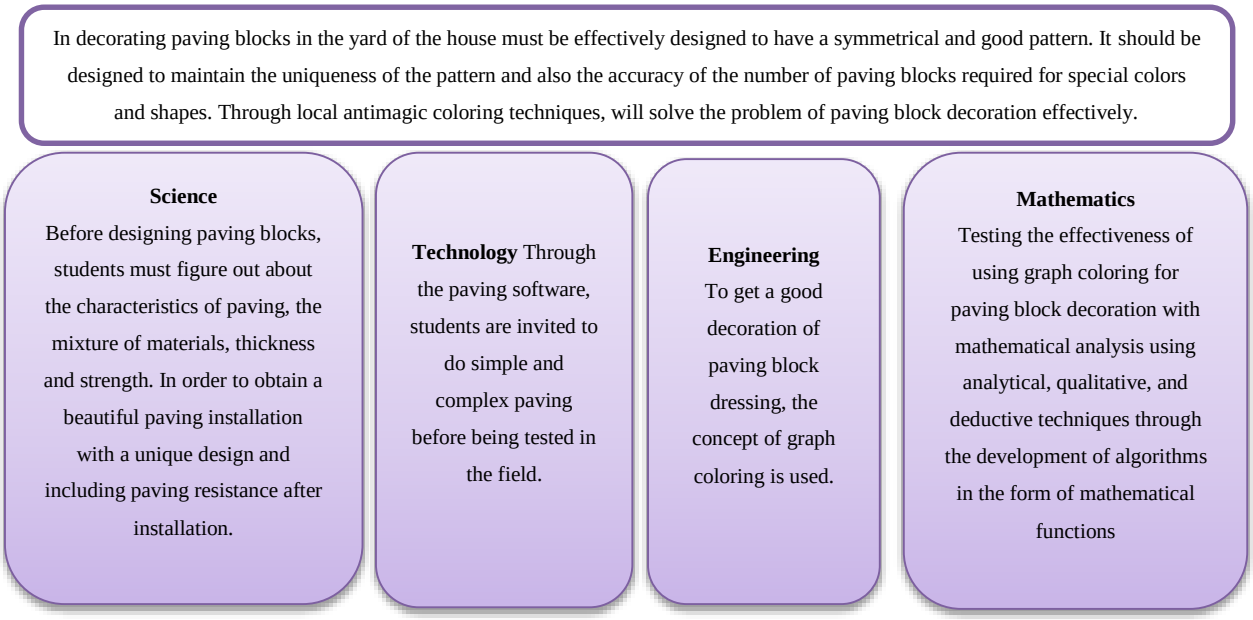



**Figure 2.** STEM elements in the cases.

In this research consider determining the number of colors and shapes of paving required. Therefore, there are several stages of a research-based learning model with a STEM approach, viz : (1) Basic problems related to the problem of the number of colors and shapes of paving required, (2) Obtaining breakthroughs by using local antimagic staining techniques, (3) Data collection related to beautiful paving block designs, (4) Development of paving block decorations using local antimagic coloring techniques, (5) Trials of the results of paving block decorations produced, (6) Reporting of research results and observation of students' conjecture thinking skills. This RBL-STEM integrated framework can be seen in detail in Figure 3.

### Student Learning Outcomes and Objectives

Learning outcomes that expected are students can develop the paving block decorations using local antimagic coloring techniques on graphs and it is also expected students can do the coloring testing whether local antimagic coloring techniques can be tested in general using analytical and qualitative approaches and get several paving block decoration possibilities.

Learning objective this research-based with a STEM approach will enable students to develop knowledge and skills in the fields of Science, Technology, Engineering, and Mathematics. Here are some things to expect from the STEM aspect:

a. In the science aspect, students are expected to:
   - Figure out of issues that related to paving block decoration, especially determining of number of the colors and shapes of paving needed.
   - Determine the application of the paving block decoration problem.
   - Analyze business strategies by preparing several paving block designs to get maximum business profits.

International Journal of Current Science Research and Review
ISSN: 2581-8341
Volume 06 Issue 01 January 2023
DOI: 10.47191/ijcsrr/V6-i1-22, Impact Factor: 5.995
IJCSRR @ 2023
www.ijcsrr.org

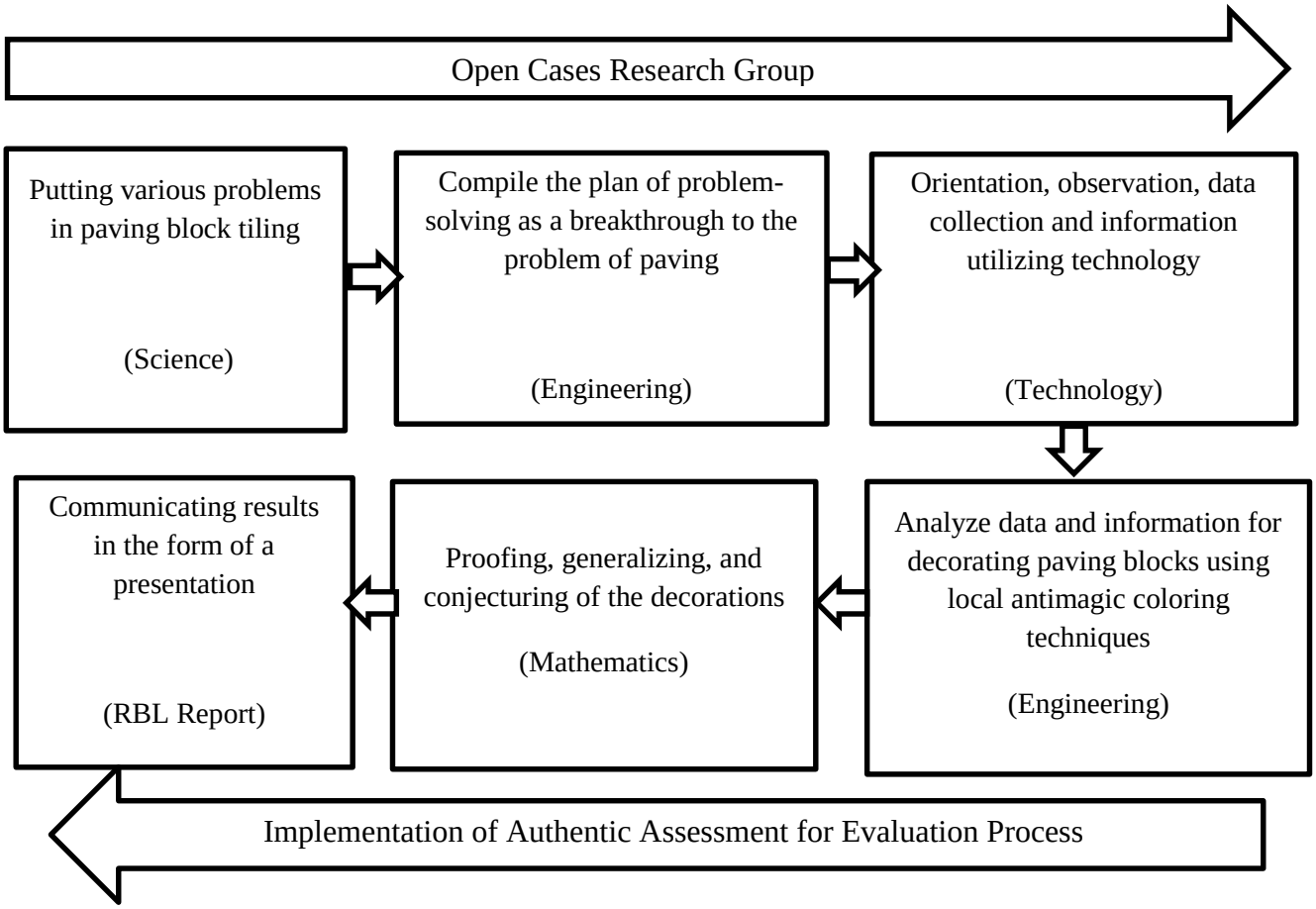



**Figure 3.** Framework of RBL-STEM.

b. In the technology aspect, students are expected to:
   - Using web browser to find information and references that related to the application of local antimagic coloring in decorating paving blocks.
   - Using website article like researchgate and so on to find recent studies related to local antimagic coloring and the problem of the number of paving block colors.
   - Utilize online drawing software to describe graphs generated from a paving block pattern.

c. In the engineering aspect, students are expected to:
   - Developing antimagic coloring local point using pattern recognition techniques
   - Applying antimagic coloring local point from the graph algorithm in developing decoration problems on paving block, especially in determining the number of paving colors required.

d. In the mathematics aspect, students are expected to:
   - Finding minimum number of paving block's color that required in one paving pattern.
   - Developing function of local antimagic coloring

**STEM Aspects for Decorating Paving Block Using Local Antimagic Coloring Techniques**

a. Scientist aspect in the cases

Paving is arrangement of multifaceted areas that cover a field completely, that is, without piercing or gaps. Paving was used by the Sumerians (circa 4000 BC) in building wall decorations formed by clay paving patterns. Currently, popular paving that often used is paving blocks. The following is an example of paving block decoration as follows:

International Journal of Current Science Research and Review
ISSN: 2581-8341
Volume 06 Issue 01 January 2023
DOI: 10.47191/ijcsrr/V6-i1-22, Impact Factor: 5.995
IJCSRR @ 2023
www.ijcsrr.org

**Figure 4.** Some examples of paving block decorations.

Paving block decorations must be effectively designed to have symmetrical and good pattern. It should be designed to maintain the uniqueness of the pattern and also the accuracy of the number of paving blocks required for special colors and shapes.


**Figure 5.** Paving block models.

b. Technology aspect in the cases

Using the Internet of Things in the technological aspect is to use some software such as (like) Drawio online. In this study, Drawio used as software to draw graphs that produced from paving block patterns. For an illustration of the use of Drawio software to draw graphs can be seen in Figure.6.

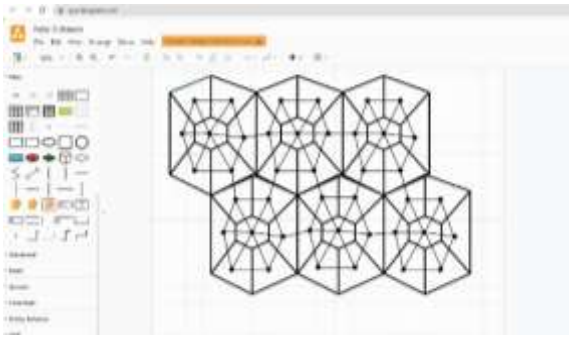


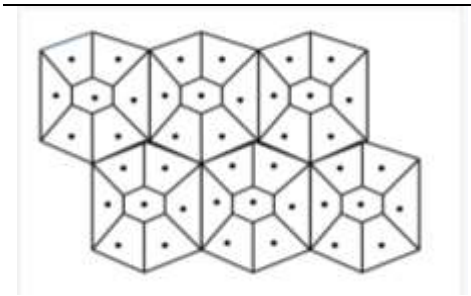
**Figure 6.** Use of online Drawio software to drawing graphs.

c. Engineering aspect in the cases

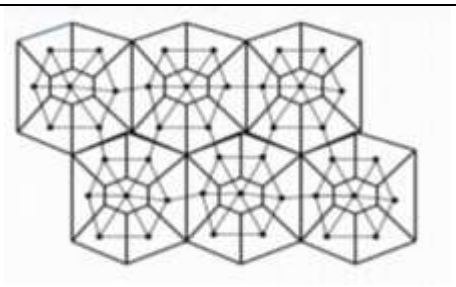
Technique that used to determine the number of colors and shapes of paving blocks for each road requires special techniques. Technique that will be used in this research is the local antimagic coloring technique. In local antimagic coloring there is a chromatic number defined as the minimum number of all graph colors that produced by the local antimagic graph labeling. To solve the problem of paving block decoration, there are steps for local antimagic coloring that can be done, viz : 1) providing point for each shape of paving block 2) connect the point with the line according to the decoration provisions of the paving block 3) drawing graph representation 4) coloring local antimagic points on the resulted graph 5) determining the number of colors in the paving block

International Journal of Current Science Research and Review
ISSN: 2581-8341
Volume 06 Issue 01 January 2023
DOI: 10.47191/ijcsrr/V6-i1-22, Impact Factor: 5.995
IJCSRR @ 2023
www.ijcsrr.org

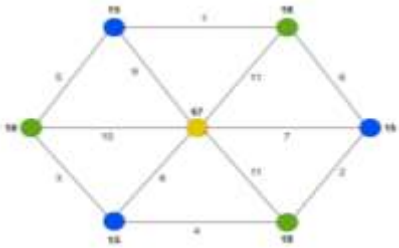
pattern obtained from the results of the chromatic number of local antimagic coloring graph 6) determining the number of paving shapes required for each road.



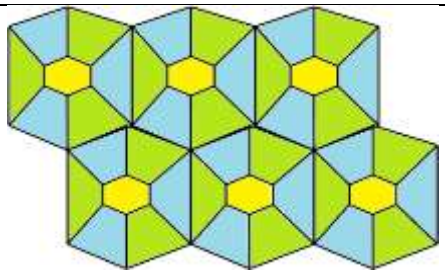
Making Point



Making Side



Representation into Graphs



Local antimagic coloring

**Figure 7.** Illustration of graph creation based on paving block pattern using online drawio software.

d. Mathematical Aspect in the cases

A simple calculation of the need for paving blocks that needed in an expanse so that there is no surplus or deficit of materials. Take for example a road that will be installed paving blocks such as Figure 5 in point 4th with the provision that one paving block pattern requires 3 green paving blocks, 3 blue *paving* blocks, and 1 yellow paving block. The road width to be installed with paving block is square with size (10×10) meters, then the area is 100 square meters. Based on the information obtained the size of the paving block in one pattern is (0.10×0.15) meters, then we take the area is 0.0005 square meters. It can be concluded that the paving block required is 100/0.0005=200,000 paving blocks with 600,000 paving blocks in green, 600,000 paving blocks in blue, and 200,000 paving blocks in yellow.

**Research-Based Learning with STEM Approach**

In this research, there are six stages of research-based learning with STEM approach. The six stages will illustrate how students doing it so in research-based learning with STEM approach on the use of local antimagic coloring techniques to improve students' conjecture skills in solving paving block decoration problems.

1. The first stage (SCIENCE) is presenting various problems in paving block tiling. Therefore, it must be determined as effectively as possible the number of colors and shapes of paving needed in order to create a beautiful paving block decoration as desired. A more detailed explanation of stage 1 can be seen in Table 1.

**Table. 1** Research-Based Learning activities with a STEM approach to paving block decorations.

| Stage 1 | Learning Activities |
|---|---|
| Asking some problems with paving block decorations **(SCIENCE)** | Teacher asked the students if they had seen the process of determining the decoration of the paving block.<br>Teacher shows the paving block decoration to the students and asks if they can develop their own paving block decoration determination or not.<br>Students work on developing of basis construction by determining the paving block decoration and trying to analyze the required number of colors and shapes of paving.<br>Students begin group discussions. |

International Journal of Current Science Research and Review
ISSN: 2581-8341
Volume 06 Issue 01 January 2023
DOI: 10.47191/ijcsrr/V6-i1-22, Impact Factor: 5.995
IJCSRR @ 2023
www.ijcsrr.org

2. The second stage is to develop a breakthrough by using local antimagic coloring techniques to improve students' conjecture skills in solving paving block decoration problems. A more detailed explanation of stage 2 can be seen in Table 2.

**Table 2**. Research-Based Learning activities with a STEM approach to local antimagic coloring as a breakthrough.

| Stage 2 | Learning Activities |
|---|---|
| Developing the related breakthrough to solve the problem of paving block decoration by using local antimagic. **(ENGINERING)** | Teacher guides students to discuss breakthroughs in solving paving block decoration problems using local antimagic on the graph.<br>Teacher explains to the students how to determine the pattern of paving blocks by using simple graph representations.<br>Students asked to searching simple local antimagic point coloring on the graph resulting from the paving block pattern. |

3. The third stage collecting data that related to the beautiful paving block design to help finding problem solutions. Students can use Drawio online software for graphing of paving block patterning and local antimagic point coloring. A more detailed explanation of stage 3 can be seen in Table 3.

**Table 3**. Research-Based Learning Activities with a STEM approach to the use of graph making software.

| Stage 3 | Learning Activities |
|---|---|
| Utilizing graph maker software, namely Drawio online software and determining coloring for local antimagic with google doc. **(TECHNOLOGY)** | Students under the guidance of the teacher try to use online software to use graphs that resulted from paving block patterns.<br>Data collection related to local antimagic coloring is carried out by browsing journals / scientific articles through research gates or other online library channels.<br>Students can using search engines such as google or national and international journal platforms that can be accessed for free<br>Developing the overview of paving block changing patterns using Drawio Online software.<br>Determines the coloring of local antimagic points on the graph. |

4. The fourth stage is applying the concept of local antimagic point coloring to the paving block decoration problem. This step begins by drawing a graph representation of the blending pattern and applying the local antimagic coloring obtained. More detailed explanation of stage 4 can be seen in Table 4.

**Table 4.** Research-Based Learning Activities with a STEM Approach on the completion of paving block decorations using

| Stage 4 | Learning Activities |
|---|---|
| Coloring points using local antimagic coloring techniques **(ENGINEERING)** | Teachers and students define graphs for coloring of local point antimagic and look for their chromatic numbers.<br>Represents a number for each point.<br>Searches for chromatic numbers by local antimagic coloring stages.<br>Then proceed with checking whether the chromatic word found is correct.<br>Identify paving block decoration problems from the chromatic numbers obtained. |

5. The fifth stage is students developing the theorem and prove that local antimagic coloring i from the paving block pattern. A more detailed explanation of stage 5 can be seen in Table 5.

International Journal of Current Science Research and Review
ISSN: 2581-8341
Volume 06 Issue 01 January 2023
DOI: 10.47191/ijcsrr/V6-i1-22, Impact Factor: 5.995
IJCSRR @ 2023
www.ijcsrr.org

**Table 5.** Research-Based Learning Activities with a STEM Approach from a specified graph.

| Stage 5 | Learning Activities |
|---|---|
| Proving and developing theorems that related to local antimagic coloring techniques. **(MATHEMATICS)** | Students determine the suitability of the number of paving colors in decorating paving blocks. Students setting the size of the road then calculate how many paving blocks are needed on one road. |

6. The sixth stage is that students writing report of the results research that has been carried out and students present the results of research that related to the use of local antimagic point coloring for paving block decoration problems. In this case, students will take a Group Discussion Focus (FGD) so that researchers can observe their conjecture skills. A more detailed explanation of stage 6 can be seen in Table 6.

**Table 6.** Research-Based Learning Activities with a STEM Approach on student worksheets.

| Stage 6 | Learning Activities |
|---|---|
| Discussion in a research group forum with RG members and other researcher about real-life problems that related to local antimagic coloring studies **(RBL Report)** | Students compiling research report in the student worksheet on the use of local antimagic point coloring to solve the problem of paving block decoration<br>Students making presentations in front of class for F group discussions FGD<br>Teacher evaluates and clarifies the results of the student's research and concludes the results of the discussion<br>Teachers observe students' conjecture skills using observation sheets |

**Instrument Framework for Assessing Students' Conjecturing Abilities**

Instrument framework for assessing students' conjecturing abilities can be seen in Table 7.

**Table 7.** Instrument framework for assessing students conjecturing.

| No | Indicator | Sub-indicator | Test Material |
|---|---|---|---|
| 1 | Observing the Case | Identifying case characteristics<br><br>Get thought/ideas | Provide an explanation why paving block decoration rules are needed in Housing area<br>Discuss thought/ideas regarding paving block decoration rules in housing area |
| 2 | Organizing Cases | Determining the stages of solving the case.<br><br>Determining the application of local antimagic coloring. | Determine the stages of problem solving of paving block decoration rules in Housing area<br><br>Determine the stages of local antimagic coloring |
| 3 | Finding and Predicting Patterns | Finding Pattern<br><br>Predicting Pattern | Define local antimagic point coloring pattern<br><br>Predict local antimagic point coloring that have been made |

International Journal of Current Science Research and Review
ISSN: 2581-8341
Volume 06 Issue 01 January 2023
DOI: 10.47191/ijcsrr/V6-i1-22, Impact Factor: 5.995
IJCSRR @ 2023
www.ijcsrr.org

| No | Indicator | Sub-indicator | Test Material |
|---|---|---|---|
| 4 | Formulating the Conjecture | Predicting existing patterns<br><br>Determine the pattern that used for the application of local antimagic coloring | Apply local antimagic coloring patterns to paving block decoration settings in housing area. |
| 5 | Validating the Conjecture | Testing on selected pattern | Test the local antimagic point coloring pattern that made, whether it is effective if it applied to paving block decoration in housing area |
| 6 | Generalizing Conjectures | Generalizing patterns | Generalize the problem of paving block decorations setting in Housing area |
| 7 | Justifying the Conjecture | Validating patterns | Validate the local antimagic coloring patterns that applied to paving block decorations in housing area |

**Learning Tools Development Follow-up**

In the development stage of the learning tool, the ADDIE (Analysis, Design, Development, Implementation, Evaluation) model that developed by Raiser and Mollenda that will be used. The model consists of analysis, designing, developing, implementation, and evaluation. First: The analysis stage is to analyze student characteristics, learning materials and processes, as well as the learning media that will be used. Second: The design stage is to design the integration of the RBL model into STEM. At this stage, teaching materials, namely syllabus, RPP, LKPD, pre-test, post-test, and other assessment instruments, are prepared by researchers. Third: The development stage, that is the trial of teaching materials and instruments to check the validity of teaching materials and practicality. The validation results are in the form of content validity, format validity, language validity, and practicality level. Fourth: Implementation stage to determine the effectiveness of RBL-STEM teaching materials in improving student conjecture in solving paving block decoration problems in Housing area by using local antimagic point coloring materials on the graph. Fifth: The evaluation stage is a reflection activity to assess whether the application of RBL model learning materials with a STEM approach can improve student conjecture in solving paving block decoration problems in Housing area by using local antimagic point coloring materials on the graph. At this stage, the use of inferential statistics is urgently needed.

## DISCUSSION

The development of an RBL-STEM learning activity framework in solving paving block decoration problems by using local antimagic coloring materials from graphs to improve student conjecture is very useful to learn. These results become guidelines in conducting further research. There are at least two more research activities that can be carried out further, viz: (1) developing RBL-STEM learning materials with the ADDIE development model, (2) Analyzing the implementation of RBL-STEM learning materials in improving student conjecture to solve paving block decoration problems using local antimagic coloring technique materials. The RBL-STEM learning activity framework is very effective in realizing student conjecture when applied in the learning class.

## CONCLUSION

Results of this study have illustrated how RBL syntax is integrated with STEM approaches. The main result is a framework of research-based learning activities with a STEM approach: the application of local antimagic coloring techniques in solving paving block decoration problems to improve student conjecture in the form of stages 1-6 and learning activities. Included in the results of this study is to develop a test instrument framework related to student conjecture. With this results, further research related to the development of devices and analysis of RBL-STEM implementation can be easily carried out.

International Journal of Current Science Research and Review
ISSN: 2581-8341
Volume 06 Issue 01 January 2023
DOI: 10.47191/ijcsrr/V6-i1-22, Impact Factor: 5.995
IJCSRR @ 2023
www.ijcsrr.org

**ACKNOWLEDGMENTS**

We would like to thank PUI-PT Combinatorial and Graph for providing guidance and support in various matters so that this paper can be completed properly. We would gratefully thank to the Faculty of Tarbiyah and Teachers Training (FITK) and also Puslitpen (LP2M), UIN Syarif Hidayatullah for the support of finishing our research.

**REFERENCES**

1. Wardani, P. L., Dafik, & 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 Physics: Conference Series*, *1211*(1). https://doi.org/10.1088/1742-6596/1211/1/012090.
2. Sutarto, S., Dafik, Hastuti, I. D., & Surahmat. (2020). An analysis of students' difficulties in conjecturing process of block paving problems. *Journal of Physics: Conference Series*, *1465*(1). https://doi.org/10.1088/1742-6596/1465/1/012073.
3. Mason, J., Burton, L. and Stacey, K. (1982). Thinking mathematically. In *Early Years Educator*. http://mehrmohammadi.ir/wp-content/uploads/2019/11/Thinking-Mathematically.pdf.
4. Cañadas, M. C., Deulofeu, J., Figueiras, L., Reid, D., & Yevdokimov, O. (2007). The Conjecturing Process: Perspectives in Theory and Implications in Practice. *Journal of Teaching and Learning*, *5*(1). https://doi.org/10.22329/jtl.v5i1.82.
5. Dafik, Riba'ah, R., Kristiana, A., & Ridlo, Z. R. (2022). The Analysis of the Implementation of Research -based Learning with STEM Approach in Improving the Students Conjecturing Thinking Skill in Solving r-dynamic Vertex Coloring Problem on Building Construction. *International Academic Journal of Education and Literature*, *3*(4), 12–23.
6. Aziza, M. O., Dafik, & Kristiana, A. I. (2021). The analysis of the implementation of research-based learning on the students combinatorial thinking skills in solving a resolving perfect dominating set problem. *Journal of Physics: Conference Series*, *1836*(1). https://doi.org/10.1088/1742-6596/1836/1/012057.
7. Kristiana, A. I., Dafik, Ridlo, Z. R., Prihandini, R. M., & Adawiyah, R. (2022). Research Based Learning and STEM Learning Activities: The Use of R-Dynamic Coloring to Improve the Students Meta-literacy in Solving a Tessellation Decoration Problem. *European Journal of Education and Pedagogy*, *3*(4), 52–60. https://doi.org/10.24018/ejedu.2022.3.4.381.
8. Ridlo, Z. R., Dafik, & 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. https://doi.org/10.13189/ujer.2020.080434
9. Dafik, Sucianto, B., Irvan, 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*(4), 593–610. https://doi.org/10.29333/iji.2019.12438a.
10. Suntusia, Dafik, & 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), 17–32. https://doi.org/10.29333/iji.2019.1212a.
11. Dafik, Joedo, J. C., & Tirta, I. M. (2022). On Improving the Students' Combinatorial Thinking Skill in Solving Rainbow Antimagic Colouring Problem on Cryptography for E-Commerce Security Systems under the Implementation of Research-Based Learning with STEM Approach. *Innovare Journal of Education*, *10*(5), 21–30. https://doi.org/10.22159/ijoe.2022v10i5.45596.
12. Nazula, N. H., Dafik, & Slamin. (2019). The profile of students' creative thinking skills in solving local antimagic vertex coloring problem in researchbased learning. *Journal of Physics: Conference Series*, *1211*(1). https://doi.org/10.1088/1742-6596/1211/1/012109.