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The Development of RBL-STEAM Learning Materials to Improve Student's Metaliteracy Thinking Skills in Solving RVAC Problems and It's Application on Design Motif Batik

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ABSTRACT: Education is a milestone in the development of every individual's mindset. With the development of the times, it is necessary to adjust in the field of education. One way is by developing learning tools using the research-based learning-STEAM model which aims to improve students' meta literacy thinking skills. The method to be used in this research is a mixed method and the research procedure to be used, namely in the form of 4D development research consists of the defining stage, the design stage, the development stage, and the dissemination stage. From the device development process, the validation score obtained in each device is 3.6 for RTM, 3.5 for LKM, 3.5 for meta literacy skills test, 3.5 for the response questionnaire, 3.5 for implementation observation, 3.4 for activity observation, and 3.56 for the questionnaire. The practicality test of the learning device obtained 3.89 with a percentage of 97.25%. The effectiveness test was divided into the completeness of the meta-literation skills test with 85% of students completed, analysis of student activities with 95.5% activity, and 81.8% for the results of positive student questionnaire responses. The device as a whole meets the criteria of validity, practicality, and effectiveness. Furthermore, the Chi-Square test was conducted. Chi-Square test results obtained Asymp. Sig. 0.004 <0.05, which means that there is an increase in the distribution of student meta-literacy skill test levels from those that tend to gather in low-medium thinking abilities with 17 low-level students and 10 medium-level students at the pre-test, to those that tend to gather in the medium-high meta literacy thinking category with 11 medium-level students and 12 high-level students at the post-test.

KEYWORDS: Antimagic Rainbow Vertex Coloring, Batik, Metaliteration Skills, RBL, STEAM.

INTRODUCTION

Education is a milestone in the development of every individual's mindset. With the development of the times, it is necessary to make adjustments in the field of education. This adjustment can be done in various ways in order to achieve the maximum level of learning in accordance with the times being experienced. Maximum educational achievement can be obtained by preparing reliable, disciplined and skilled human resources. Skills in technology and creativity are needed to face the current and future era.

In response to the need to increase student interest and skills in Science, Technology, Engineering, and Mathematics (STEM), STEAM (with the addition of 'Arts') was developed. STEAM combines "arts" with STEM learning for the purpose of enhancing student engagement, creativity, innovation, problem-solving skills, and other cognitive benefits that have often been emphasized in the context of math and science education (Liao, 2016). The arts in STEAM can also facilitate transdisciplinary integrated learning that provides a deeper understanding of the material being taught for effective learning (Liao, 2016).

The achievement of effective learning developed by the government is one of them with student-centered learning which makes students the main focus in learning. One of the appropriate learning methods is Research-based learning (RBL). This method implements a student-centered curriculum learning approach in improving mindset to achieve the expected level of success (Humaizah et al., 2022).

Many theories in mathematics are directly related to everyday problems, one of which is graph theory. One of the topics owned by graph theory is rainbow vertex antimagic coloring. Where rainbow vertex antimagic coloring (RVAC) is a combination of rainbow vertex coloring and vertex antimagic labeling (Marsidi et al., 2021). The use of RVAC in everyday life problems can be exemplified in the decision to color batik motif designs.

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Batik is a traditional Indonesian art that has existed since ancient times. With the development of the times, the demand for batik is increasing which has caused the batik industry to switch from written batik to stamped batik and batik printing (Poon, 2020).. This happens because with the demand for mass production of batik in a short time, batik craftsmen use the Internet of Things to save the time required. The utilization of the Internet of Things will show batik motif designs that are more precise and have high accuracy (Mohammed et al., 2019).

Utilization of the Internet of Things and high skills can help, solve everyday problems. This skill can refer to students' metaliteracy skills (Humaizah et al., 2022). Metalliteracy skills are divided into 4 domains, namely behavioral, cognitive, affective and metacognitive. The 4 domains must be possessed by students to solve problems using graph theory and its improvement in metaliteracy skills. Through this metaliteracy approach, each learner will be encouraged to imagine themselves in the role of active learners, such as producers, collaborators, publishers, and teachers (Mackey, 2020).

Maximum improvement of metaliteracy skills can be done with the assistance of supporting learning materials. Where learning materials help and facilitate the teaching and learning process and provide experience to students in order to achieve predetermined goals. Learning materials that will be used to support metaliteracy skills with the RBL-STEAM method include the Student Learning Plan (RPS), syllabus, and Student Worksheet (LKM).

METHOD

The research procedure that will be used is development research. The stages used in development research refer to the 4D-Model. Statistical tests in this study used the chi-square test through SPSS software.

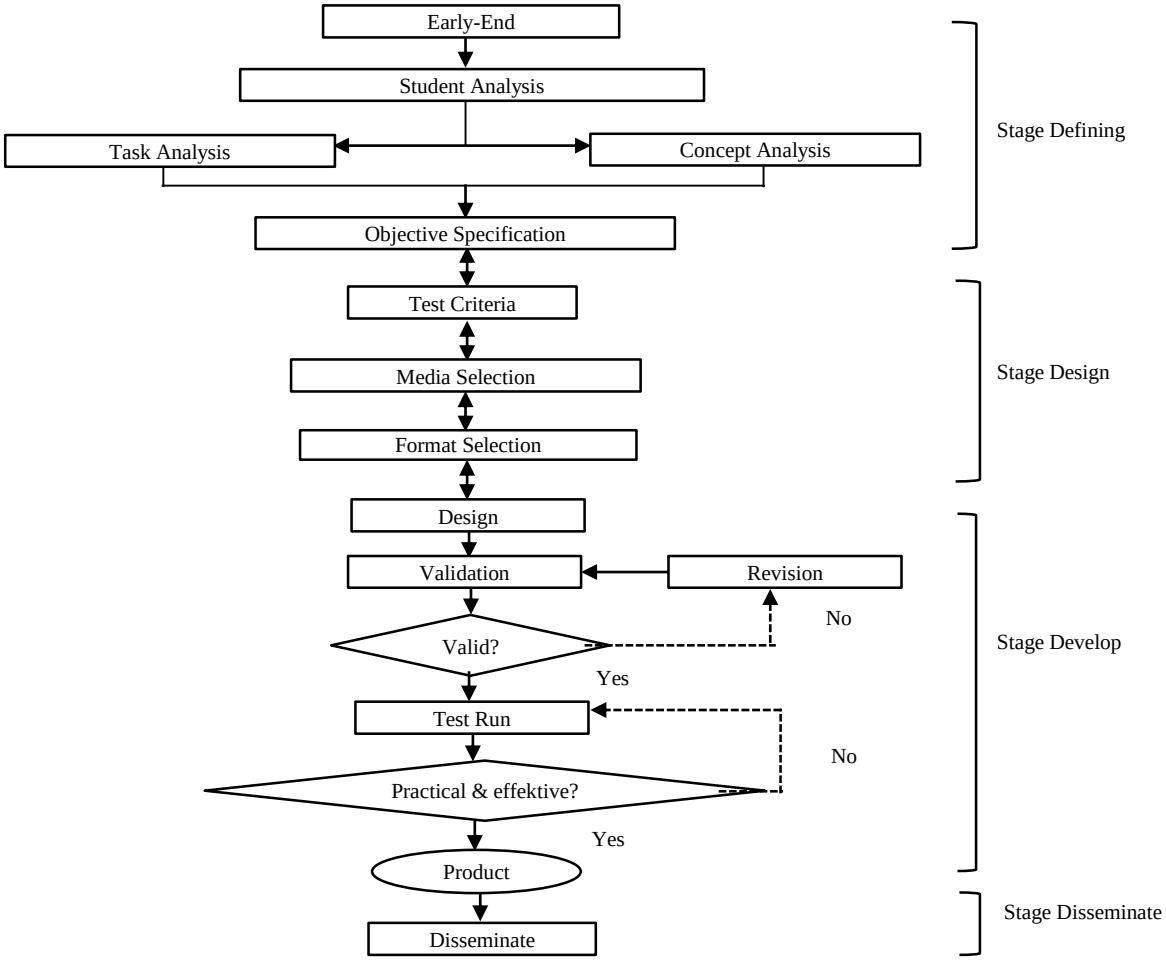

Fig. 1. Design Model 4D

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RESEARCH FINDING

This framework is developed based on the activities carried out by students. The first stage that students must do is to understand the problem given and then determine how to solve the problem, followed by finding data and information through related literature. Batik motif design coloring patterns must be designed symmetrically, regularly, and pay attention to the use of color. Based on this, it requires accuracy in determining the type of color choices used in the design of batik motifs to make it look practical and aesthetic. The following problems are presented regarding the design of batik line motifs using the RVAC concept as in Figure 4.1 below.

SCIENCE	*TECHNOLOGY*	*ENGINEERING*	*ART*	*MATHEMATICS*
Analysis of batik motif design based on coloring, layout and symmetry.	Use of software geogebra software for drawing graphs, corel draw to expand image.	Application coloring concept concept of rainbow vertex antimagic coloring by representing graphs on batik motif design	Arrangement and addition of design elements to batik motifs	Usage calculation math in determine permutations set of colors on batik motif design

Fig. 2. STEAM Aspects

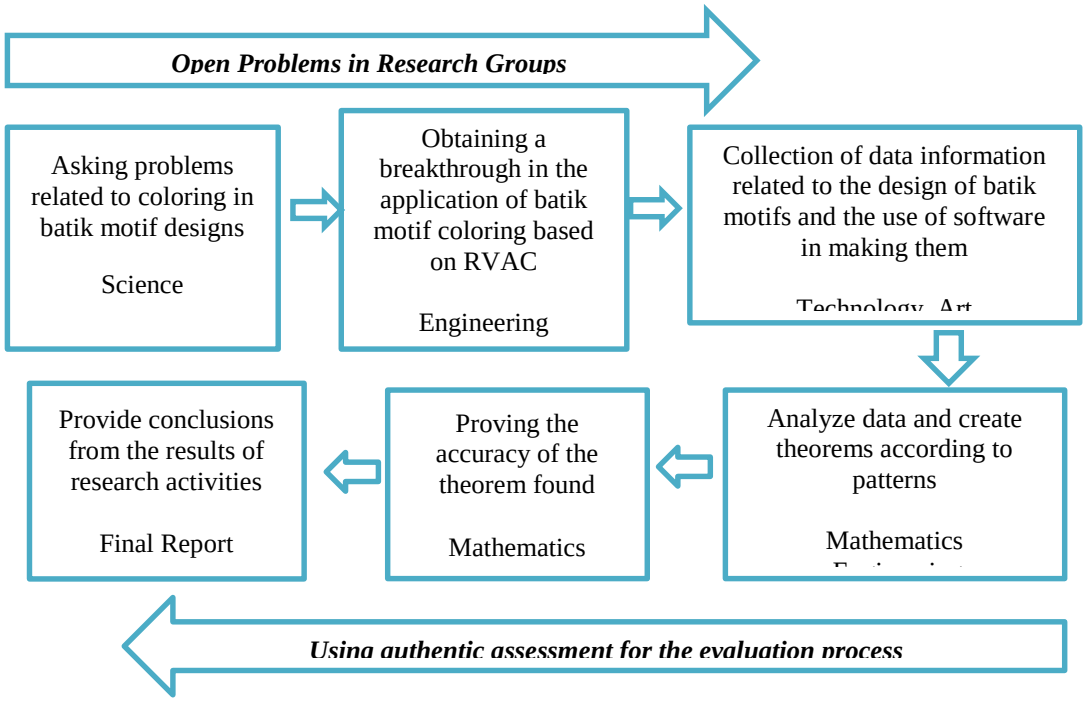

Fig. 3. RBL-STEAM Stages Chart

The expected results in this study from the problems presented are the formation of a coloring that can be developed to form a consistent and colorful coloring pattern by fulfilling the Rainbow Vertex Antimagic Coloring concept. Therefore, the RBL-STEAM model used in this study uses 6 stages such as (a) Providing problems regarding the design of batik motifs and analyzing the use of colors so as to create good and attractive colors, (b) Planning solutions to the problems given related to rainbow vertex antimagic coloring, (c) Collecting information related to the problem and things that will be the solution to the problem and determining the arrangement and coloring pattern suitable for the batik motif, (d) Building theorems about rainbow vertex antimagic coloring from several graphs, (e) Proving the theorems built on the topic of rainbow vertex antimagic coloring, and (f) Discussion and group forum presentation regarding problem-solving and theorems obtained on the topic of rainbow vertex antimagic coloring.

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The first development process refers to the Thiagarajan model (4D) which includes the Defining stage, namely the activities of the beginning-end analysis, student analysis, material concept analysis, task analysis, and goal analysis. The initial-end analysis was carried out by observing learning by observing the course of learning and conducting interviews with the responsible discrete mathematics lecturer. The basic problem found by researchers is the lack of enthusiasm and understanding of students in the continuity of learning. The development of this learning material is expected to provide solutions for students who have difficulty learning and understanding the concept of Rainbow Vertex Antimagic Coloring (RVAC). The existence of this material is expected to make it easier for students to understand the concept of RVAC and apply it to a graph. In addition, students can also use the Internet of Things (IoT). Student analysis was conducted on undergraduate students of Tadris Mathematics, Faculty of Tarbiyah, Kiai Haji Achmad Siddiq Jember State Islamic University. Students are expected to be directly involved in the learning process and can work together in groups. The task analysis given is in the form of coloring problems for local wisdom batik motif designs that apply the concept of coloring in graphs. As for concept analysis, this process is carried out to identify, detail, and organize systematically the concepts that will be learned by students on the topic of rvac. Based on the preliminary analysis conducted, the concept analysis produced the following concept map:

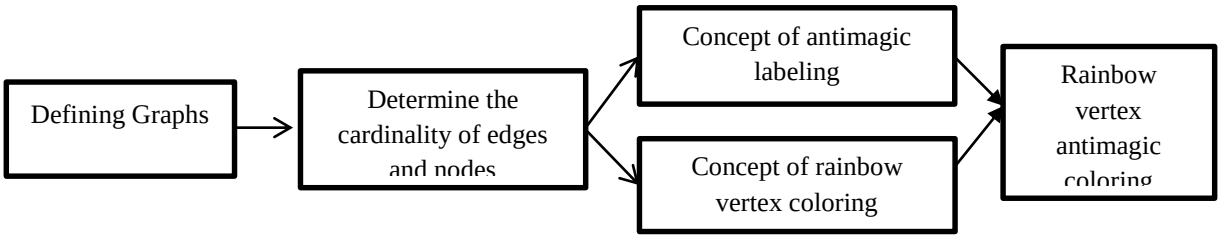

Fig. 3. Analyze the concept of rainbow vertex antimagic coloring

The second stage in this research, namely the planning stage, aims to design learning devices to be developed including, (a) Preparation of tests and instruments (b) Media selection, (c) Format selection; (d) Initial design. Test preparation is carried out based on predetermined learning indicators. The test prepared in this study is in the form of a description that contains STEAM and is related to the topic of rainbow vertex antimagic coloring, besides that the test is equipped with a grating along with scoring guidelines. The media selection process is adjusted to student analysis, concept analysis, and previous task analysis. the selected media include power point as a teaching medium that can support understanding to students, as well as the development of Student Worksheets (LKM) which contain indicators of meta literation. In addition, the application of designing basic batik motifs is also used, adjusted to student understanding in using the application itself. The choice of format in the development of learning materials aims to design content, select learning strategies, and learn resources to support learning activities. In this case, the learning model used is STEAM-based research-based learning that contains the topic of rainbow vertex antimagic coloring and contains several things that can measure students' meta-literacy skills based on available meta-literacy indicators. The initial design is the entire design of learning materials that must be done before the trial. The learning materials are in the form of Student Task Design (RTM), Metalliteracy Skills Test, Student Worksheet (LKM), and questionnaires. The front cover of the LKM and Metaliteracy Skills Test can be seen in Figure.

Fig. 4. Cover of LKM and Meta literacy Skills Test

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Furthermore, the development stage (Develop) is where all devices developed are validated by validators, and revisions are made according to the suggestions given. The results of device validation from both validators can be seen in Table 1.

Table 1. Results of Validation of Learning Materials and Instruments

Aspects assessed		Format	Content	Language and Writing	Average score of all aspects
RTM	Mean	4	3,5	3,5	3,6
	Percentage	100%	87,5%	87,5%	90%
LKM	Mean	3,6	3,6	3,16	3,45
	Percentage	90%	90%	79%	86,25%
Meta Literacy Skill Test	Mean	3,5	3,57	3,3	3,5
	Percentage	87,5%	89%	83,3%	87,5%
Response Questionnaire	Mean	4	3	3,75	3,58
	Percentage	100%	75%	93,75%	89,58%
Implementation Observation	Mean	3,75	3,5	3,5	3,58
	Percentage	93,75%	87,5%	87,5%	89,58%
Activity Observation	Mean	3,75	3,37	3,33	3,5
	Percentage	93,75%	84,37%	83,25%	87,5%
Questionnaire	Mean	3,685	3,685	3,685	3,685
	Percentage	92,125%	92,125%	92,125%	92,125%

After being declared valid, a trial and dissemination stage was held. In the trial stage, the device was tested on Discrete Mathematics class students consisting of 30 students as the object of the trial. The trial process was accompanied by an observer and one lecturer. At first, students were given a pre-test to find out the initial abilities possessed by students about the topic to be studied. After completing the pre-test for 30 minutes, the learning took place smoothly. Learning was given about the concept of rainbow vertex antimagic coloring in batik motif design applications. To help students' understanding of learning, the LKM is given. At the end of the activity, students are given a post-test question to determine the final ability of students after the learning takes place. Furthermore, the practicality test of this learning material was carried out by analyzing student learning activities and lecturer activities during the learning process. The overall average score of the observation results was 3.87 and a percentage of 96.93%. Therefore, it can be concluded that the learning device prepared meets the practicality category.

Table 2. Recapitulation of observation results of the implementation of the learning process

Aspects assessed	Average	Percentage
Format	3.9	97.5%
Isi	3.73	93.3%
Bahasa dan Tulisan	4	100%
Average score of all aspects	3.87	96.93%

After being declared practical, then the device will be tested for effectiveness. Where the effectiveness is seen from three categories, namely the completeness of the meta-literation skills test, the analysis of student activities, and the results of student responses. The results of the answers collected by students were obtained by 30 students getting scores above 60. Therefore, there are 85% of students completed and met one of the criteria for a device to be called effective. Based on student activity analysis data, the percentage of student activity is 95.1%. So based on the criteria of student activity observation data, it meets the criteria of being very active.

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Table 3. Recapitulation of student activity observation results

Aspects assessed	Average	Percentage
Syntax	3.8	95%
Social System	3.73	93.3%
Reaction and Management Principles	3.92	97%
Average score of all aspects	3.82	95.1%

The results of student responses were obtained from the results of student responses given in hard file format then students who filled out the questionnaire. The recapitulation of student response scores is shown in Table 4. The analysis results show that the learning atmosphere item shows a positive response of 90,9%. Furthermore, the highest positive response is on the item of novelty of the LKM material. Overall, the average positive percentage of statements is 89,82% and the negative percentage is 8,47% so it can be concluded that the majority of students have a positive response to the learning that has taken place and the learning materials used during learning. This means that the three requirements for effective learning material have been fulfilled.

Table 4. Recapitulation of student response data

Aspects to be assessed	Percentage Answers	
	Yes	No
Student enjoyment of the learning component	88.65%	11.3%
Novelty of the learning component	80.74%	7.22%
Students' interest in learning	90.9%	9.1%
Students' level of understanding of the language used	93.4%	6.8%
Students' level of understanding of the questions presented	88.65%	11.25%
Students' level of interest in learning materials	95.5%	4.5%
Students' enjoyment during problem discussion	90.9%	9.1%
The average score of all aspects	89.82%	8.47%

The last stage is the dissemination stage which will be carried out to Mathematics Education lecturers in the form of books. Dissemination will also be carried out by utilizing the Internet of things. The utilization of IoT used is such as Youtube, Facebook, Whatsapp, and various other social media. Dissemination is also done by saving the device on Google Drive which will later be shared in the form of a link to the teacher as a reference to help learning become more effective.

The quantitative analysis stage in this study will be carried out with the chi-square test which is carried out to determine whether there is an increase in the distribution of meta literacy skill levels. The graph of the distribution of pre-test and post-test data in Figure 5 (a), shows that the lowest value for the pre-test is 35 and the highest value is 77. As for the post-test, the lowest value obtained is 55 and the highest value is 96. Meanwhile, the frequency distribution data is divided into 5 categories, namely M1 as a student with a very high mastery level (ST), M2 as a student with a high mastery level (T), M3 as a student with a medium mastery level (S), M4 as a student with a sufficient mastery level (C) and M5 as a student with a low mastery level (R). Where based on Figure 4.11 (b), the pre-test results obtained by students M1 to M5 consecutively consisted of 0, 3, 14, 11, and 2. Meanwhile, for many students is based on the post-test results consecutively from M1 to M5, namely 3, 15, 9, 3, and 0. These results are obtained based on the criteria for the student mastery level interval (TPM).

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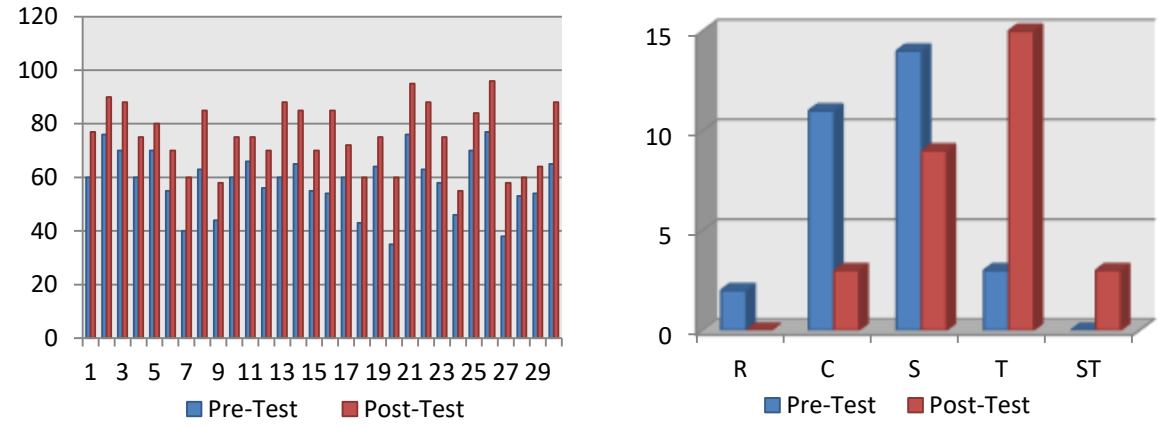
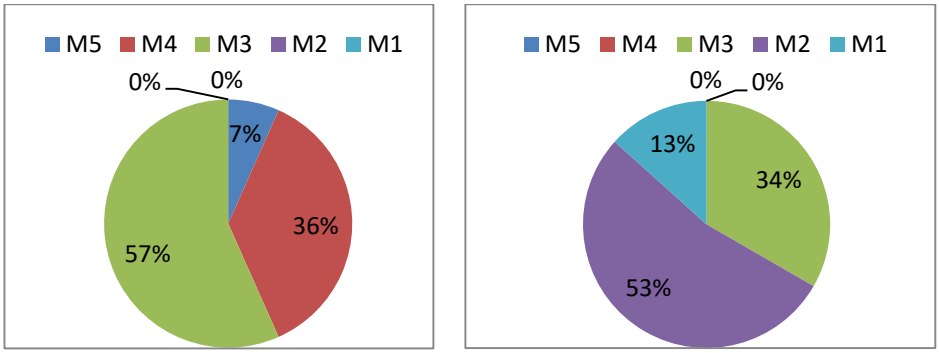


(a) (b)

Fig. 5. (a) Distribution Chart of Pre-test and Post-test Scores (b) Skill Distribution

The percentage of pre-test and post-test scores can be seen in Figure 4.12. Based on the post-test results in Figure 6(b), 13% of M1 students, 34% of M2 students, 53% of M3 students, and 0% of M4 and M5 students. After being given learning that is adjusted to the device that has been developed, there is a percentage difference in student meta literacy skills. Where, based on the pre-test results in Figure 6(a), it was obtained that 0% were owned by M1 and M2 students, 36% were owned by M3 students, 57% were owned by M4 students, and 7% were owned by M5 students.



(a) (b)

Fig. 6. Percentage Chart of Score Intervals (a) Pre-test (b) Post-test

The percentage level of meta-literacy skills can be seen in Figure 7 where the skills will be divided into 3 categories, namely high, medium, and low. This percentage is based on the number of students who meet the criteria for each sub-indicator. The criteria in question will be called a high category if it meets $11<SI\leq17$, a medium category if it meets $7<SI\leq11$, and $0\leq SI\leq7$ if it is a low category. SI itself stands for the indicator score that is fulfilled. In Figure 7, it can be noted the increase in the percentage level in each category. At the high meta literacy skill level, there was an increase from 3 students (10%) to 12 students (40%), from 10 students (33%) to 11 students (37%) at the medium category level, and 17 students (57%) to 7 students (23%) in the low. Category.

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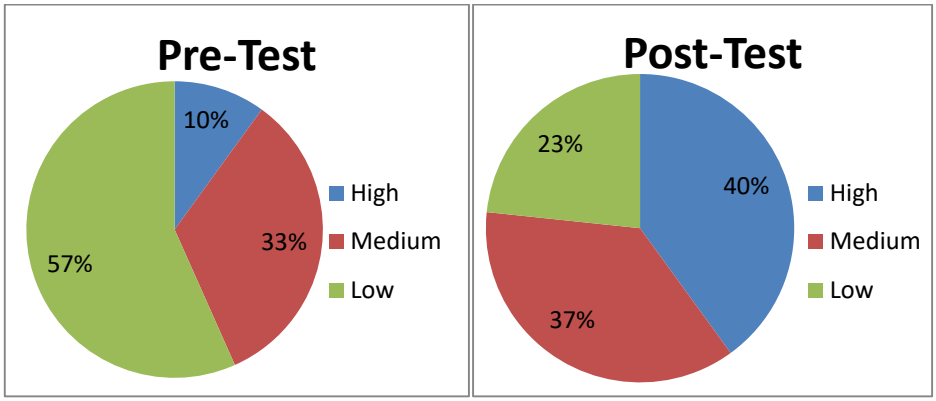

Fig. 7. Percentage of Students' Meta literacy Skill Level

Furthermore, the results of the pre-test and post-test were conducted in Chi Square to strengthen the results of the distribution in the class. This statistical test was carried out using SPSS which is presented in Figure 8. From the Chi-Square test results obtained Asymp. Sig. 0.004, which means the test results show less than 0.05. When the chi-square test results have an Asymp. Sig. value is less than 0.05, this indicates that there is a significant increase in the distribution of levels of meta literacy thinking skills.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	15.413[a]	4	.004
Likelihood Ratio	19.178	4	.001
Linear-by-Linear Association	12.657	1	.000
N of Valid Cases	30		

Fig. 8. Results of Chi-Square

This can also be seen from the difference in the distribution of skill levels in Figure 9. This means that the results of students' meta-literacy thinking skills at the time of the pre-test show that they tend to gather in the low-medium thinking ability category while the students' meta-literacy thinking skills at the time of the post-test show that they tend to gather in the medium-high meta-literacy thinking category, so it can be seen that the RBL-STEAM learning tool can significantly increase the distribution of student meta-literacy skill levels.

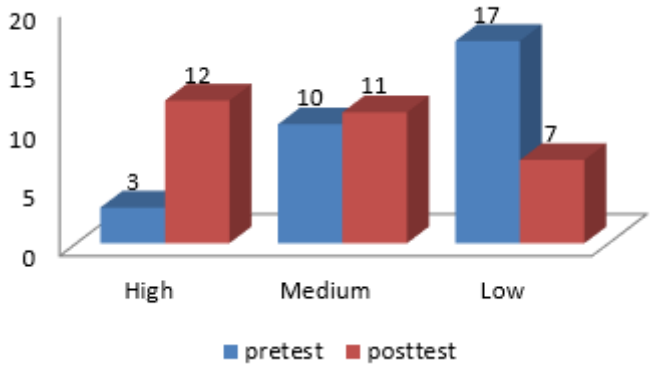

Fig. 9. Category Chart of Meta Literacy Skill Levels

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DISCUSSION

The developed materials is a research-based mathematics learning materials with a STEAM approach to improving students' meta-literacy skills to analyze the set of rainbow vertex antimagic coloring in solving batik motif design coloring problems. The developed device 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. This device has met the validity criteria of $3.25 \leq Va < 4$, the suggestions from the validators did not change the device as a whole, but only a small part. The validity score obtained in each device is 3.6 for RTM (valid), 3.5 for LKM (valid), 3.5 for Metaliteracy Skills Test (valid), 3.5 for response questionnaire (valid), 3.5 for implementation observation (valid), 3.4 for activity observation (valid) and 3.56 for questionnaire (valid). This mathematics learning device has also met the criteria of practicality, and suggestions from practitioners do not change the device as a whole, but only a small part. The learning implementation observation score resulted in 3.89 with a percentage of 97.25%, which means that the learning was very well implemented. In addition to being valid and practical, the device also meets the effective criteria. An average of 91% of students in this trial class were classified as complete students and the response from students was positive. Based on the test results, researchers found 30 students who scored above 60. This means that 85% 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.

Based on the pre-test and post-test results obtained, it can be concluded that students experienced an increase in meta-literacy skills, which initially around 13% of students had low meta-literacy skills, 33% had sufficient meta-literacy skills, 54% had moderate meta-literacy skills, 0% had high meta literacy skills and 0% who had very high abilities increased to 0% of students had low meta literacy skills, 0% of students had sufficient meta literacy skills, 37% of students had moderate meta literacy skills, 56% of students had high meta literacy skills and 7% of students had very high meta literacy skills. This is in line with research conducted by Dafik et al. (2023), Kristiana et al., (2022), and Kurniawati et al., (2022) regarding the impact of implementing RBL-STEM learning in improving students' meta literacy thinking skills. The addition of the element "art" in STEM can certainly increase students' ability to solve problems. This is emphasized by Zayyinah et al. (2022) and Parhusip et al. (2023), where the STEAM approach is needed in the 21st century in improving students' abilities in learning mathematics. From some previous studies, it can be seen that the application of RBL and STEAM itself can improve the students' mental literacy skills themselves.

After data collection, hypothesis testing with Chi Square was carried out which showed that the pre-test and post-test values were Asymp. Sig. 0.004, which means that there is an increase in the level distribution of students' meta-literacy skills, this is in line with research conducted by Izza et al. (2023), Zayyinah et al. (2022), and Dhanil (2023) which states that the application of RBL learning and the STEAM approach provides a difference in the abilities obtained by students, which means that there is an increase in the level distribution of students' meta literacy skills from pre-test to post-test.

CONCLUSION

Research-based learning activities with the STEAM approach, including (1) Providing problems regarding the design of batik motifs and analyzing the use of colors so as to create good and attractive colors, (2) Planning solutions to the given problems related to RVAC, (3) Collecting information related to problems and things that will be the solution to the problem and determining the arrangement and coloring patterns suitable for the batik motif, (4) Building theorems about RVAC from several graphs, (5) Proving the theorems built on the topic of RVAC, and (6) Group forum discussions and presentations regarding problem-solving and theorems obtained on the topic of RVAC.

The developed devices have met the valid criteria. The validity scores obtained in each device are 3.6 (RTM), 3.5 (LKM), 3.5 (Metaliteration Skills Test), 3.5 (Response Questionnaire), 3.5 (Implementation Observation), 3.4 (Activity Observation), and 3.56 (Questionnaire). The practicality test of the learning device obtained 3.89 with a percentage of 97.25%. The effectiveness test is divided into the completeness of the meta literacy skills test with 85% of students complete, analysis of student activities with 95.5% activity, and 81.8% for the results of positive student questionnaire responses. The device as a whole meets the criteria of validity, practicality, and effectiveness. The chi-square test results obtained Asymp. Sig. 0.004 <0.05, this indicates that there is an increase in the distribution of the level of meta literacy thinking skills from those that tend to gather at the low-medium level of thinking skills (17 low-level students-10 medium-level students) at the pre-test, to tend to gather in the category of medium-high meta literacy thinking levels (11 medium-level students-12 high-level students) at the post-test.

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