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The Development of RBL-STEM Learning Materials to Improve Students' Computational Thinking Skills in Solving Rainbow Vertex Antimagic Coloring Problems and It's Application for Batik Motif Design

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ABSTRACT: Computational thinking is thinking process that is needed in formulating problems and solutions, so that these solutions can be effective information processing agents in solving problems. Indicators of computational thinking consist of problem decomposition, algorithmic thinking, pattern recognition, abstraction and generalization. To improve higher-order thinking skills, we apply RBL learning integrated with STEM approach and their aplication to batik matif design. To improve students' thinking skills, it is necessary to develop tools that support the success of learning activities. The learning tools that have been developed meet the criteria of valid, practical, and effective. The validity score obtained on each device is 3.58 for the student assignment plan (RTM), 3.47 for the student worksheet (LKM), and 3.64 for the learning outcomes test (THB). The observation result of the learning implementation score was 3.72 with a percentage of 93%. In addition to being valid and practical, the material also meets the criteria for effectiveness. On average, 95% 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 23 students who scored above 60. This means that 82% of students in this class have completed and met one of the effectiveness criteria. Student response questionnaires also give more positive responses than negative responses.

KEYWORDS: Computational Thinking, RBL-STEM, Rainbow Vertex Antimagic Coloring

INTRODUCTION

Learning approach in schools is growing along with the development of science and technology (Mufidati et al., 2023). The STEM approach is one of the approaches used. The term STEM stands for Science, Technology, Engineering and Mathematics. STEM-based learning focuses on solving problems in everyday and real life with the help of science, technology, engineering and mathematics. Research based learning is a learning system that uses authentic-learning, problem solving, cooperative learning, contextual (hand on and mind on), and inquiry approaches based on the philosophy of constructivism. Research-based learning plays an important role in improving students' thinking skills (Dafik, 2019). To improve students' thinking skills, it is necessary to develop tools that support the success of learning activities. Learning tools that need to be developed to support the success of a research-based learning activity are student worksheets (LKM), learning outcomes tests (THB), and monographs. The learning tools used must be in accordance with the learning objectives. Therefore, the development of learning tools is very necessary to fulfil the availability of materials according to the demands of the curriculum, characteristics, objectives, and demands for problem solving (Mursyidah, 2023).

Research-based learning is a learning model that is associated with analysis, synthesis, and evaluation activities, and improves the ability of students and lecturers in terms of assimilation and application of knowledge (Izza et al., 2023). Learning that uses a research-based learning model helps students develop various mathematical thinking skills. Previous research related to RBL includes Suntusia et al. (2019) examining the effectiveness of RBL-based learning for second-level arithmetic sequence problem solving. Nazula et al. (2019) conducted research related to the profile of students' creative thinking in RBL-based learning. Meanwhile, Ridlo et al. (2021) examined the effectiveness of research-based learning integrated with STEM to improve computational thinking skills and gave results that research-based learning integrated with STEM has a significant effect on computational thinking skills.

Computational thinking is a thought process required in formulating problems and their solutions, so that these solutions can become effective information processing agents in solving problems (Wing, 2010). Therefore, computational thinking is one of the important abilities to be honed from an early age because in the information age, the era of industry 4.0 or society 5.0, humans live in the real world and at the same time in the digital world (Dafik et al., 2023)

Graph theory is one of the sciences that help in solving various problems in various disciplines (Mursyidah et al., 2023). In the field of mathematics, graphs have many benefits in solving social problems and daily life problems. The usefulness of graphs is to represent various discrete objects and the relationships between them. The visual representation of a graph is to represent an object as a vertex, while the relationship between objects is represented by lines (Dafik et al, 2021). Some of the graph topics that have been studied are antimagic labelling and rainbow vertex colouring. In this research, in addition to discussing the development of materials, rainbow vertex antimagic colouring will be discussed. Rainbow vertex antimagic coloring defined by marsidi et al. (2022), Let $G(V(G), E(G))$ be a connected graph of size q and $f : E(G) \rightarrow \{1, 2, 3, \dots, q\}$ be a labeling of a graph G. The function f is called a rainbow vertex antimagic labeling if for any two vertices u and v in $V(G)$, all internal vertices in path $u - v$ have different weight. The vertex weight denoted by $w_f(u)$ for every $u \in V(G)$, where $w_f(u) = \Sigma_{uu' \in E(G)} f(uu')$. If each edge of G is assigned with the color of the vertex weight $w f(u)$, then G admits a rainbow vertex antimagic coloring. The $rvac(G)$ is a notation of rainbow vertex antimagic connection number of graph G which means the minimum colors taken over all rainbow vertex antimagic coloring induced by rainbow vertex antimagic labeling of graph G.

Based on these problems, the development of learning materials using the Research Based Learning model with a STEM approach will be carried out to improve students' computational thinking skills to solve the problem of antimagic rainbow vertex colouring and its application to batik motif design. Therefore, in this research the author chose the topic the Development of RBL-STEM Learning Materials to Improve Students' Computational Thinking Skills Solving in Rainbow Antimagic Vertex Coloring Problems and It's Application to Batik Motif Design.

METHOD

The stages that are used in this study refer to the development of the Thiagarajan 4-D Model which consists of the defining stage, the design stage, the development stage, and the dissemination stage. The data that was obtained from the observation of student activities during the learning process were statistically tested using parametric statistical tests. The statistical test in this study used R-Shiny software through a learning center and a virtual statistics laboratory that can be accessed through the http://statslabrshiny.fmipa.unej.ac.id/RProg/BasicStat/, website, which was built by Tirta (2016). There are two variables in this study, namely the free variable and the bound variable. The free variables tested are research-based learning materials with STEM approach, while the bound variables are students' computational skills. Furthermore, paired sample ttest was carried out on pre-test and post-test results. The Thiagarajan 4-D model learning device development scheme can be seen in Fig. 1.

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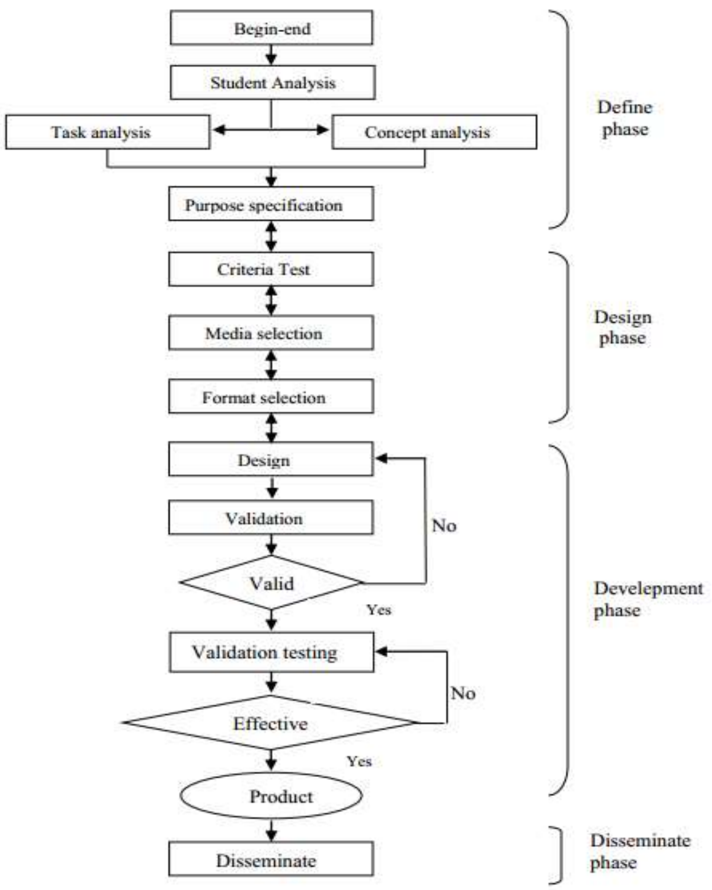

Fig. 1. Desain Model 4D

RESEARCH FINDINGS

Batik is a craft that has high artistic value and has become part of Indonesian culture. The main element in batik is the motif, so batik cannot be separated from the motif as illustrated. The colouring pattern of batik motif design must be designed symmetrically, regularly and pay attention to the use of colour. based on this, it is necessary to be accurate in determining the type of colour choice used in batik motif design so that it looks practical and aesthetic. We can use the concept of rainbow vertex antimagic coloring to solve the problem by representing batik motif design into graph. The colouring pattern of batik motif design must be designed symmetrically, regularly and pay attention to the use of colour. based on this, it is necessary to determine the type of colour choice used in batik motif design to make it look practical and aesthetic.

This research uses research-based learning with STEM approach so that students can learn and develop skills in the fields of Science, Technology, Engineering, and Mathematics. STEM explanation is as follows: (1) Science, students are expected to understand the problems of batik design motifs, analyze the layout of batik motif designs on fabrics and pay attention to the use of colors, so as to create good and attractive colors. (2) Technology, students are expected to use a web browser to identify the concept of rainbwon vertex antimagic coloring and disjoint union concepts, use the site, sciencedirect and others to find the latest studies related to concepts, and utilize GeoGebra Classic Fx Draw and Corel Draw Software to draw graphs on batik design motif. (3) Develop techniques and apply the concept of rainbow vertex antimagic coloring based on the concept of disjoint union, from the graph algorithm in developing the batik design problem of line motifs. (4) Mathematics, students are expected to rainbow vertex antimagic coloring based on the graph concept motif batik design problems, determine the basic design of batik based on graph representation, and determine coloring based on the side weight of the graph that has been obtained. An explanation of the STEM aspects of the study can be seen in Fig. 2.

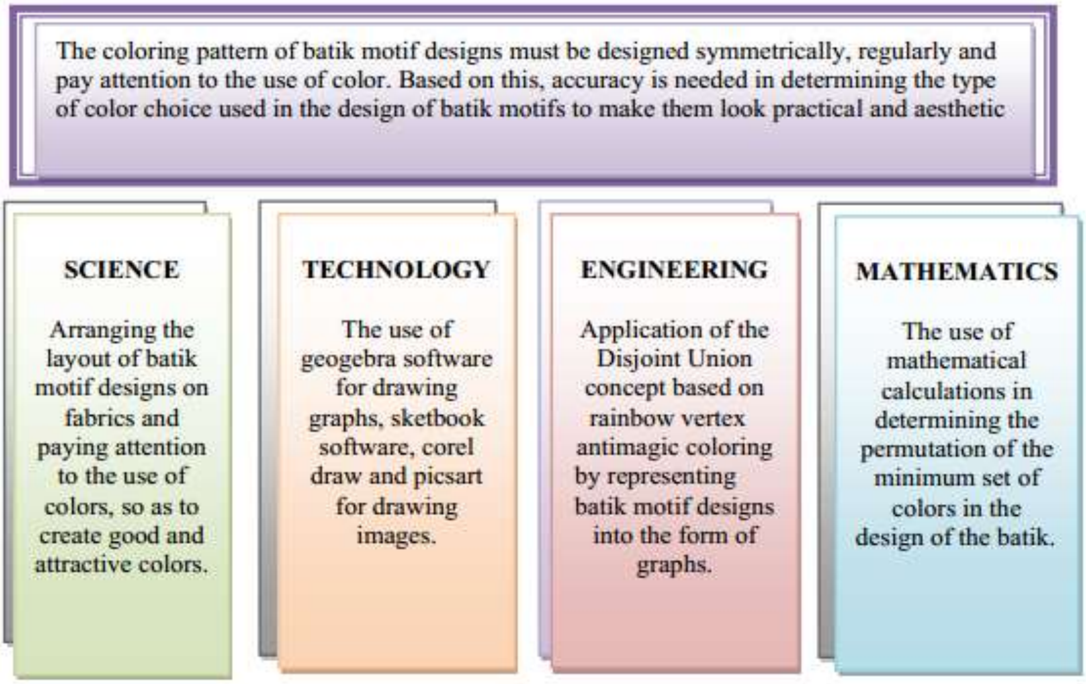

Fig. 2. STEM aspect in research

Therefore, the RBL-STEM model shows in Fig. 3 will perform the following stages (1) Posing problems on several problems, (2) Developing solutions to real-world problems, (3) Collecting data while tracing sources related to things needed for the problem-solving process and understanding them, (4) Building theorems on the topic, (5) Proving the accuracy of the solution, (6) Presenting the results of student research that relate to real-world problems.

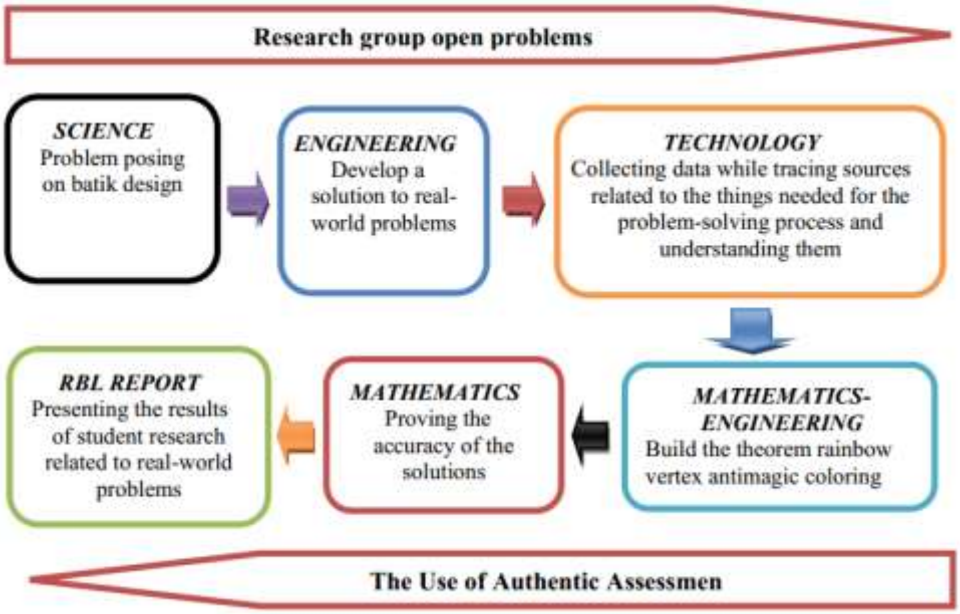

Fig. 3. Stages of RBL-STEM in research

The process of developing STEM-based research-based learning tools is used to determine the effect of these learning tools on students' computational skills in problem-solving batik motif design and rainbow vertex antimagic colouring analysis. This

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development process refers to the Thiagarajan (4D) model which includes the stages of defining, designing, developing, and disseminating.

The first stage is the defining stage. The defining stage consists of the early-end analysis stage, student analysis, concept analysis, and task analysis. The initial analysis stage is carried out to determine problems in learning device development activities so that the resulting devices are expected to provide solutions to students who are hampered in learning in the classroom. Rainbow vertex antimagic coloring was chosen as the topic of study because this topic belongs to a new topic that combines two topics, namely antiajaib labeling and rainbow vertex coloring. The existence of learning on this topic is expected to add insight to students and can be used as a reference to compile the final project. Solve of this problem requires students who are active and creative so that they can find the expected coloring patterns. A suitable learning model is RBL-STEM learning to improve students' computational skills.

The next stage is student analysis. Students of the Graph Application class found it a little difficult to understand the rainbow vertex antimagic coloring at first. But then they can understand the problem and the concept that given. After the student analysis stage, task analysis and concept analysis are carried out. Task analysis aims to identify the main skills necessary in learning that correspond to the curriculum. Meanwhile, concept analysis is carried out to identify, detail, and systematically compile the concepts studied by students on the topic of rainbow vertex antimagic coloring. The results of the resulting concept analysis can be seen in Fig. 4

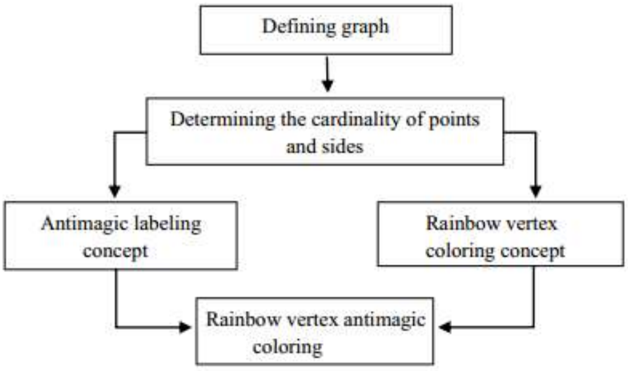

Fig. 4. Rainbow Antimagic Coloring Concept Analysis

The second stage is the design stage. The design stage has four stages, namely test preparation criteria, media selection, format selection, initial design. The cover of LKM and THB can be seen in Fig 5.

Fig. 5. LKM and THB page cover

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The next stage is the development stage. At the development stage, all developed devices are validated by validators and revised according to the suggestions that given. The device was validated by two validators of lecturers of the Mathematics Education Study Program, FKIP, Jember University. The result of validation in general is that all learning tools in the form of RTM, LKM, and THB can be used with a little revision.

The validation results of the Student Assignment Design received a score of 3.58, the validation results of student worksheets were 3.47, and the validation results of the learning outcomes test were 3.64. Based on the validation results, it can be concluded that the learning tool is valid. The validation results of the three learning devices can be seen in Table 1, Table 2, and Table 3

Table 1: RTM Validation Recapitulation Results

Assessed aspects	Average score	Average percentage
Format	3,75	93,75%
Content	3,5	87,5%
Language and Writing	3,5	87,5%
Overall aspect average score	3,58	89,5%

Tabel 2: LKM Validation Recapitulation Results

Assessed aspects	Average score	Average percentage
Format	3,5	87,5%
Content	3,4	85%
Language and Writing	3,5	87,5%
Overall aspect average score	3,47	86,75%

Tabel 3: THB Validation Recapitulation Results

Assessed aspects	Average score	Average percentage
Format	3,75	93,75%
Content	3,5	87,5%
Language and Writing	3,67	91,75%
Overall aspect average score	3,64	91%

In general, based on the assessments of both validators, the device can be used with minor revisions. The detailed assessment results of the two validators can be seen in Table 2.

Table 4: Assessment by Validators

Advocacy Device	**Validator 1**	**Validator 2**
Student Assignment Design (RTM)	Can be used with few revisions	Can be used with few revisions
Student Worksheet (LKM)	Can be used with few revisions	Can be used with few revisions
Learning Outcomes Test (THB)	Can be used with little revision	Can be used with little revision

The trial of the validated and revised device was conducted on students of teory graph class of the Mathematics Education Study Programme, University PGRI Argopuro of Jember. The class that was tested consisted of 28 students as the object of the trial. The trial process was accompanied by observers and one lecturer. Observers consisted of five people and were taken from master's students of Mathematics Education FKIP, University of Jember. The lecturer who observed in this trial was Eric Dwi Putra, M.Pd. The results of the trial assessment consisting of observer assessments and student work results were used to assess the effectiveness and practicality of the device.

The practicality test of learning tools is carried out by analyzing student learning activities and lecturer activities during learning. Analysis of student and lecturer activities based on observation sheets on the implementation of the learning process assessed by five observers that taken from Master of Mathematics Education students. The results of the score recapitulation can be seen in Table 4. Based on Table 4, the overall average score of 3.72 is obtained, which means that the device meets the practical criteria.

Table 4: Results of Recapitulation of Observation Results on the Implementation of the Learning Process

No	Assessed Aspects	Average	Precentage
I.	**Syntax**		
1.	Level of implementation of all stages of learning	3,67	91,67%
2.	Implementation of the sequence of learning activities reflects computational skills-oriented research-based learning	3,5	87,5%
II.	**Social System**		
1.	Level of implementation of the desired situation (atmosphere) (group formation, discussion, questioning, arguing, expressing opinions, mutual respect in work)	3,5	87,5%
2.	Level of interaction in learning (student-student and student-lecturer)	3,83	95,83%
3.	Implementation of lecturer behavior embodies computational principles and concepts in computational-based learning	3,67	91,67%
III.	**Principles of Reaction and Management**		
1.	Implementation of lecturers in accommodating and providing opportunities for students to ask questions, submit opinions, and respond to RBL-STEM learning tools to improve computational skills	4	100%
2.	Level of implementation of lecturer behavior provides assistance, instruction, guides students in RBL-STEM learning to improve computational skills	3,67	91,67%
3.	The level of implementation of lecturer behavior provides motivation in RBL-STEM learning to improve computational skills	3,5	87,5%
4.	Level of implementation of lecturer behavior involves students actively in RBL-STEM learning to improve computational skills	3,83	95,83%
5.	Level of implementation of lecturers facilitates students to learn with the RBL-STEM approach to improve computational skills	4	100%
Overall average score		**3,72**	
Overall average percentage score		**93%**	

Once the device is declared practical, it will be tested for effectiveness. The effectiveness test can be determined based on three criteria, namely the completeness of the student learning outcomes test, student activity analysis, and student response results. The first criterion is the completeness of learning outcomes. The results of the score recapitulation can be seen in Table 5. Based on Table 5, an overall average score of 3.77 is obtained, which means that the device meets the practical criteria.

Table 5: Student Activity Observation Sheet Recapitulation Results

No	Assessed Aspects	Average	Precentage
I.	**Introduction**		
1.	Students have attention and a sense of motivation towards the presentation of learning objectives	3,75	96,87%
2.	Students listen to the lecturer's explanation regarding the study material that will be studied	4	
II.	**Main Activities**		

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1.	Students form groups	3,75	
2.	Students have attention and motivation to the presentation of references in the form of RBL-STEM-based research journals	3,5	
3.	Students collect data through discussions in RBL-STEM learning	3,5	
4.	Students present data obtained on RBL-STEM-based LKM	3,75	92,85%
5.	Students analyze data obtained at RBL-STEM-based LKM	4	
6.	Students present the results of the discussion	3,5	
7.	Students take pre-test and post-test enthusiastically on RBL- STEM learning	4	
III.	**Closure of Activity**		
1.	Students can make conclusions from learning activities	3,75	93,75%
Overall Aspect average score		**3,77**	**94,41%**

This mathematics learning tool has also met the criteria of practicality, and suggestions from practitioners did not change the device as a whole, but only a small part. The learning implementation observation score resulted in 3.75 with a percentage of 93%, which means that the learning was carried out very well. Besides being valid and practical, the device also fulfils the effective criteria. The average student in this trial class is classified as a complete student and the response from students is positive. Based on the test results, researchers found 23 students who scored above 60. This means that 82% of students in this class have completed and fulfilled one of the effectiveness criteria. The student response questionnaire also gave more positive responses than negative responses. One of the objectives in this study was to analyse students' computational skills through test results.

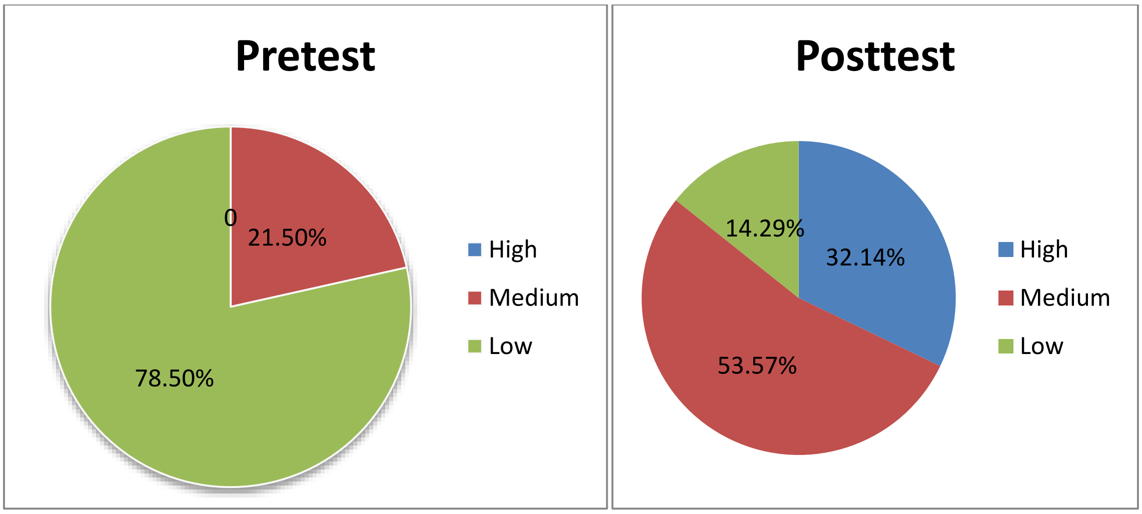

Fig. 6. Percentage of Student Computational Skill Level

Based on Fig. 6., it can be known that there are two levels of computational thinking skills when students do pretests, namely medium level with a percentage of 21,5% and low level with a percentage of 78,5%. In addition, there are three levels of computational thinking skills when students take the posttest, namely high level with a percentage of 32,14%, medium level with a percentage of 53,57%, and low level with a percentage of 14,29%. In Fig. 7, it also shows that there is an increase in students' ability from pretest to posttest.

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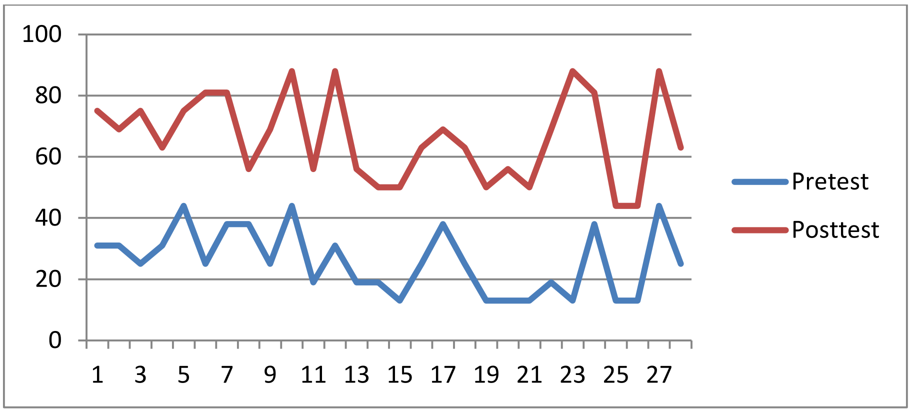

Fig. 7. Pretest and Posttest Value

The next step is to test the normality on the pretest value and the posttest value. Test normality using the R application available online. After the normality test, a p-value of 0.35 was obtained, which indicates that the data is distributed normally. Normality test results can be seen on Fig. 8.

statistic	p.value	method	data.name
0.94	0.09	Shapiro-Wilk normality test	datasetInput()[, input$var.y]
0.94	0.09	Shapiro-Wilk normality test	datasetInput()[, input$var.y]

Fig. 8. Normality Test Results

```
Uji-T 2-Kelompok Berpasangan: Data= IMPOR Y1= postest Y2= pretest

        Paired t-test

data:  datasetInput()[, input$var.yt2p1] and datasetInput()[, input$var.yt2p2]
t = 20.125, df = 27, p-value < 2.2e-16
alternative hypothesis: true mean difference is not equal to 0
95 percent confidence interval:
 36.40300 44.66842
sample estimates:
mean difference
       40.53571
```

Fig. 9. Paired Sample t-Test Result

After the data is declared normal, the next statistical test carried out is a paired sample t test using the application R. Results of the paired sample t test on Fig. 9. indicates that the p-value obtained is $2{,}2 \times 10^{-16}$. *p-value* < 0,05 indicates that there is a significant difference between the pretest value and the posttest value. Therefore, it can be concluded that there is an influence on the application of research-based learning tools with the application of STEM. Paired sample t-test was carried out on pretest and post-test results. Before that, a normality test is carried out. Test this statistic using r-shiny online software, is http://statslab-rshiny.fmipa.unej.ac.id/RProg/BasicStat/.

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DISCUSSION

Research-based learning tools with a developed STEM approach must meet valid criteria, practical, and effective criteria. Furthermore, the device was validated by two validators of mathematics education lecturers FKIP Jember University. The validation results show that this learning tool belongs to the category of valid, practical, and effective.

This research-based learning model is recommended in the implementation of education in order to produce higher student motivation, can improve student learning outcomes, and be able to apply what is learned in everyday life. The purpose of researchbased learning is to make students more active, creative, and able to think more critically when compared to students who use conventional learning. This is in accordance with Suntusia (2019) who explained that learning carried out in conventional classes causes students to tend to be passive and lack the drive to develop their potential. The results of the application of learning tools have been proven to significantly improve students' computational thinking skills. This can be seen from the results of the paired sample t test between the pretest value and the posttest value which shows an influence in the form of increasing student learning outcomes.

CONCLUSION

Devices that have been developed and meet valid criteria are piloted in the trial class. The validity score obtained on each device is 3.58 for the student assignment plan (RTM), 3.47 for the student worksheet (LKM), and 3.64 for the learning outcomes test (THB). The observation result of the learning implementation score was 3.72 with a percentage of 93%. In addition to being valid and practical, the material also meets the criteria for effectiveness. On average, 95% 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 23 students who scored above 60. This means that 82% of students in this class have completed and met one of the effectiveness criteria. Student response questionnaires also give more positive responses than negative responses.

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