The Development of RBL-STEM Learning Materials in Improving Students' Generalization Thinking Skills to Solve Local Vertex Irregular Reflexive Coloring Problem

Adidtiya Dwi Harliyuni, Dafik & Slamin
Department of Post Graduates of Mathematics Education, PUI-PT Combinatorics and Graph, CGANT, University of Jember, Jember, Indonesia

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ABSTRACT

Generalization is the process of drawing general or simple conclusions about a problem. The stages of mathematical generalization consist of four stages, namely perception of generality, expression of generality, symbolic expression of generality, and manipulation of generality. There needs to be a learning model that can improve students' generalization thinking skills, one of which is by using the Research Based Learning (RBL) model. The Research Based Learning (RBL) model is also supported by the STEM (Science, Technology, Engineering, and Mathematics) approach to make it easier for students to develop generalization thinking skills. In this study, there searchers developed a material using the Research Based Learning (RBL) model and the STEM (Science, Technology, Engineering, and Mathematics) approach, with the aim of improving students' generalization skills. The results of developing research-based learning materials in with the STEM approach after testing the materials in and analyzing them, it can be concluded that the materials in meet the valid, practical, and effective criteria.

Keywords: Generalization, Research Based Learning, STEM

INTRODUCTION

Generalization is one part of inductive reasoning. Inductive reasoning consists of three types, namely: generalizations, analogies and causal or causal relationships (Herdinan, 2010). Generalization is a reasoning process based on examining sufficient things, then arriving at conclusions for all or most of these things. The stages of mathematical generalization according to Mason (2010) consist of four stages, namely perception of generality, expression of generality, symbolic expression of generality, and manipulation of generality.

Learning models that can improve students' generalization thinking skills, one of which is by using the Research Based Learning (RBL) model. Research Based Learning is one of the learning models developed by constructivism. Research Based Learning (RBL) is a learning model that leads to analysis, synthesis, and evaluation activities as well as improving students' and lecturers' abilities in terms of assimilation and application of knowledge (Widyawati, 2010). This Research Based Learning (RBL) model can be used as a learning reform in higher education to improve the quality of learning.

The Research Based Learning (RBL) model is also supported by the STEM approach. The STEM approach is learning that is associated with four components which stand for Science, Technology, Engineering and Mathematics (Fathoni et al, 2020). STEM learning has the goal of improving students' skills in four fieldsof science, namely science skills, operating technology, problem-solving technical skills and math skills thatare suitable for current application.

The STEM approach can be applied to graph theory because it can be applied in four categories in STEM. Using graph theory can help in this research process. One of the topics of graph theory is Local Vertex Irregular Reflexive Coloring and learning materials in are needed to maximize the research process, so that students can develop generalization skills. Let X(G) be the chromatic number of the proper coloring in G . For injection and , where for is a natural number. The associated weights of the nodes under f is .

METHODS

The development of this device is a development research that uses a 4D model. The 4D model is a model described by Thiagarajan and Semmel in 1974 which consists of several stages, namely the define stage, the design stage, the develop stage, and the disseminate stage.

This study uses model with a STEM approach that enables students to learn and develop knowledge and skills in the fields of Science, Technology, Engineering, and Mathematics. The following is an explanation of STEM in research, namely (1) Science, students are expected to be able to understand the problems presented regarding the placement of terminal types based on the number of passengers and determine which terminals have the potential to be crowded and which are not potentially crowded; (2) Technology, students are expected to be able to use the internet in finding understanding and solutions to the problems provided. In addition, students can search for and study the latest studies on the topic of local vertex irregular reflexive coloring; (3) Engineering, students are expected to be able to develop the topic of local vertex irregular reflexive coloring in graphs, and be able to solve problems regarding sensors and terminal types based on the number of passengers in bus transportation flows; (4) Mathematics, students can apply the concept of local vertex irregular reflexive coloring in graphs and graph formation from bus transportation flows, starting from labeling the vertices and edges of the graph and calculating the weights of the points in the graph.

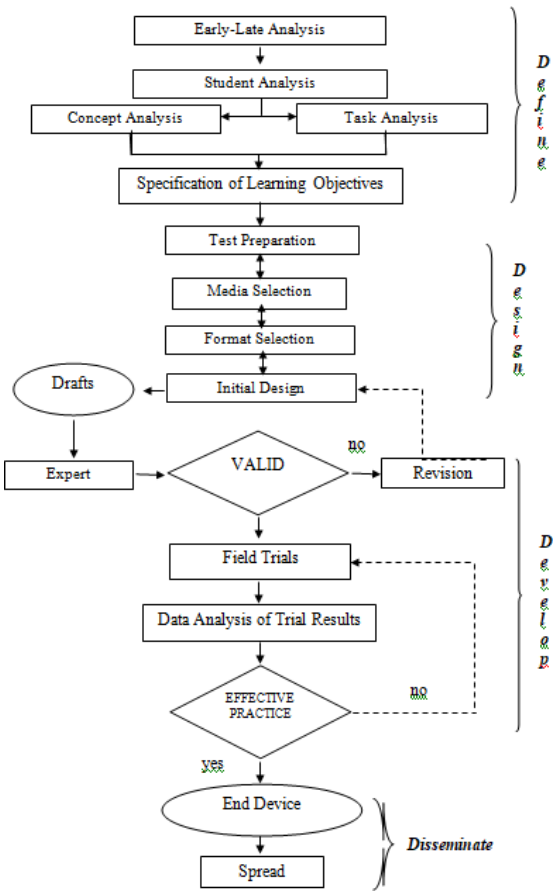

Chart 1. 4D Model Research Flow

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The above can be explained as follows.

Science	Technology	Engineering	Mathematics
An overview of bus transportation routes in East Java and a description of the problems regarding the number of Automatic Passenger Counting	Matlab, FX Draw and Microsoft Excel software	Determining the type of terminal using the concept of local vertex irregular reflexive coloring	Mathematical calculations in determining the type of terminal use the concept of local vertex irregular reflexive coloring

This development process refers to the Thiagarajan model (4D) which includes the stages of defining, designing, developing, and disseminating. This defining stage has the goal of establishing and defining learning needs by analyzing the objectives and limitations of the material to be delivered. The steps at this stage, namely the initial-end analysis in this study to determine the basic problems needed in the development of learning materials in and students in this study were used to obtain data on the characteristics of undergraduate students in Mathematics Education, FKIP, University of Jember. Concept analysis in this study aims to identify, detail and systematically arrange the concepts to be studied on the topic of local vertex irregular reflexive coloring. Furthermore, task analysis and specification of learning objectives are carried out.

Furthermore, the design stage aims to design learning devices that will be used so that examples of learning devices are obtained. The step at this stage is the preparation of the test used in this study is the pretest and posttest. After that, the selection of media and format is carried out, then the initial design of the device or instrument. The learning materials in and instruments are) Student Worksheets (LKM) and Learning Outcomes Tests (THB). First, the Learning Outcomes Test (THB) is a test used for the pretest and posttest which is prepared with material regarding local vertex irregular reflexive coloring. The results of this test are used with the aim of measuring students' generalization skills. Pretest and posttest are done individually to determine students' abilities before learning and after learning, namely the students' final abilities.

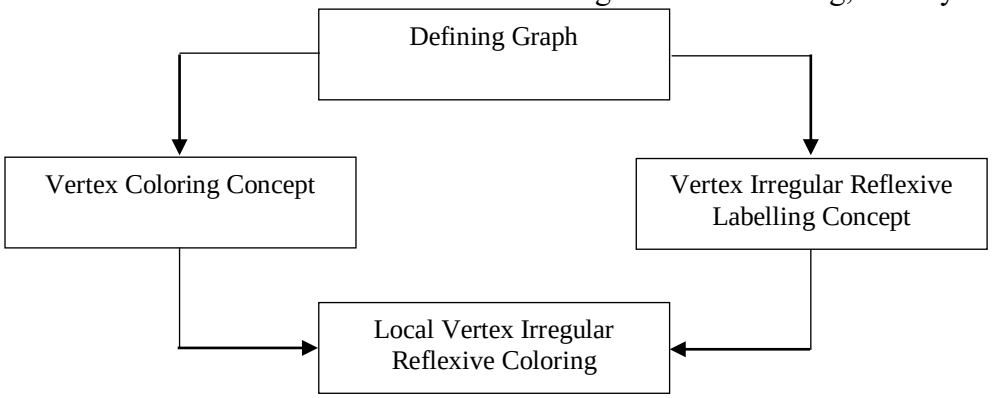

Figure 1. Concept Analysis of Local Vertex Irregular Reflexive Coloring

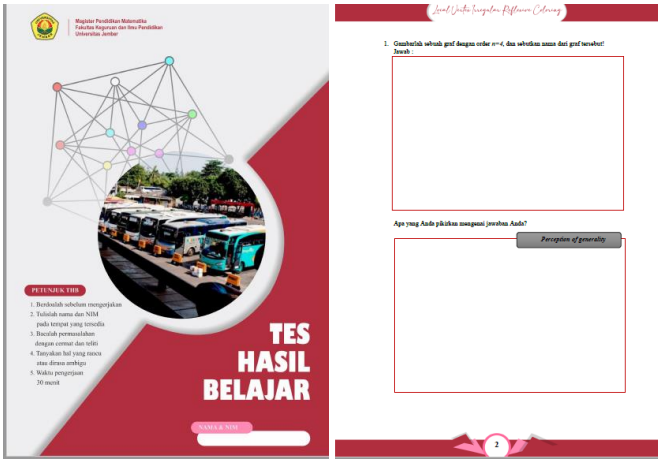

Figure 2. THB design

Second, the Student Worksheet (LKM) contains STEM problems, namely the problem of the number of bus passengers by determining which terminals are potentially crowded and which are not potentially crowded using a graph artificial neural network. As well as determining the type of terminal using the concept of local vertex irregular reflexive coloring.

The third stage is the development stage. At this stage all the materials in developed were validated by the validator and revised according to the suggestions given. After the device was revised and declared valid, a trial was held in the Combinatorics class of the Mathematics Education Study Program, FKIP University of Jember.

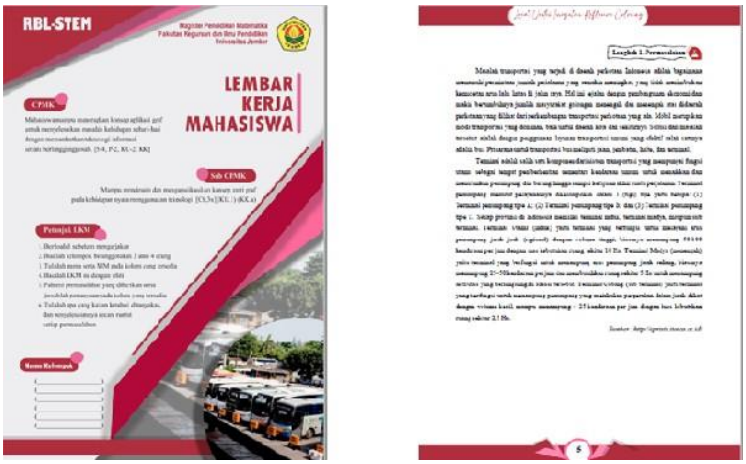

Figure 3.LKM Design

RESULTS

Validity test

Devices that meet the validity criteria are $3.25 \leq Va < 4$**.** Suggestions from validators do not change the device as a whole, but only a small part. The following is the recapitulation of THB from each validator with values Va = 3.5 and valid category.

Table 1. THB summary

No	Rated aspect	Validators		Average	Percentage
		1	2		
I. Format					
1	Clarity of test instructions	4	4	4	100%
2	The presentation of THB is interesting	3	3	3	75%
II. Fill					
1	The material presented is in accordance with CPL, CPMK,Sub CPMK, and learning objectives	4	4	4	100%
2	Suitability of test questions with Local vertex irregularreflexive coloring material	4	4	4	100%
3	The issues raised are according to indicators of metalliteration skills	4	3	3,5	88%
4	The difficulty level of the test questions is according to thestudent's ability	3	3	3	75%

No	Rated aspect	Validators		Average	Percentage
		1	2		
5	The number of questions and the level of difficulty inaccordance with the allotted time	3	4	3,5	88%
6	The problem of test questions can measure students' metalliterate thinking skills	3	3	3	75%
III. Language and Writing					
1	The questions are formulated in simple language and do notcause multiple interpretations	3	3	3	75%
2	Use terms that are easy to understand	4	4	4	100%
3	Formulated using correct Indonesian language rules (EYD)	3	4	3,5	88%
Total Aspect Score				38,5	
Overall Average Score of Aspects				3,5	

Furthermore, the results of the LKM recapitulation from each validator with values Va = 3.41 and valid category.

Table 2.LKM Recapitulation

No	Rated aspect	Validators		Average	Percentage
		1	2		
I. Format					
1	The LKM has clear work instructions	3	4	3,5	88%
2	The LKM systematics is written clearly	3	3	3	75%
3	Interesting LKM presentation	3	3	3	75%
II. Fill					
1	Material is presented according to learning objectives,CPL, CPMK, and Sub CPMK	4	4	4	100%
2	The truth of the concept or material	4	4	4	100%
3	The issues raised are according to indicators ofgeneralization and STEM-based skills	3	3	3	75%
4	Each activity uses the RBL stages	4	3	3,5	88%
5	The activities presented can be used to analyze students'metal literate abilities	3	3	3	75%
III. Language and Writing					
1	Use language that is in accordance with the correctIndonesian language rules (EYD)	3	4	3,5	88%
2	The language used is easy to understand and does notcause multiple interpretations	4	3	3,5	88%
3	The language used is communicative	3	4	3,5	88%
Total Aspect Score				37,5	
Overall Average Score of Aspects				3,41	

Practicality Test

The practicality test of this learning device is carried out by analyzing the implementation of research trials,

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namely on student learning activities and lecturer activities during learning. Observation of the implementation of research in class was carried out by five observers who were taken from Master of Mathematics Education students. Based on the observations, the overall average score of the aspects obtained was 3.92 and the percentage was 98%. A device is said to be practical if the observation results are good or very good. So, it can be concluded that the device developed based on the results of observations meets the practicality criteria, namely very good/very high.

Table 3. Performance Observer Results

No	Rated aspect	Observers					Average	Percentage
		1	2	3	4	5		
I. Syntax								
1	The level of implementation of all stages of learning	4	4	4	4	4	4	100%
2	The implementation of the sequence of learning activities reflects research-based learning oriented to generalization skills	4	4	4	4	4	4	100%
II. Social System								
1	The desired level of implementation of the situation (atmosphere) (forming groups, discussing, asking questions, debating, submitting opinions, respecting each other at work)	4	4	4	4	4	4	100%
2	Level of implementation of interaction in learning (students, and students-lecturers)	4	4	3	3	3	3,4	85%
3	The implementation of lecturer behavior embodies the principles and concepts of metal literation in research-based learning	4	4	4	4	4	4	100%
III. Principles of Reaction and Management								
1	Teacher implementation in accommodating and providing opportunities for students to ask questions, submit opinions, and provide responses	4	4	4	4	3	3,8	95%
2	The level of implementation of the lecturer's behavior provides assistance, instructions, guides students in learning	4	4	4	4	4	4	100%
3	The level of implementation of the lecturer's behavior provides motivation in learning	4	4	4	4	4	4	100%
4	The level of implementation of teacher behavior involves students actively in learning	4	4	4	4	4	4	100%
5	The level of implementation of the lecturer facilitates student learning	4	4	4	4	4	4	100%
Total Aspect Score							39,2	
Total Average Score of All Aspects							3,92	
Percentage of Overall Aspects								98%

Effectiveness Test

Data analysis of the effectiveness of the device was divided into two, namely, based on the results of observations of student activities and student responses. Observational data of student activity in participating in learning were analyzed. Based on the results of observations, the percentage obtained is 97%. So, it can be concluded that the device developed based on the results of observations meets the criteria, which is very high.

Table 4. Activity Observer Results

NO	RATED ASPECT	Observers					Average	Percentage
		1	2	3	4	5		
I. INTRODUCTION								
1	Students have attention and a sense of motivation towards the presentation of learning objectives	4	4	4	4	4	4	100%
2	Students listen to the lecturer's explanation regarding the study material to be studied	4	4	4	4	4	4	100%
II. CORE ACTIVITIES								
1	Students form groups	4	4	4	4	4	4	100%
2	Students have attention and motivation towards presenting references in the form of research journals	4	4	3	4	4	3,8	95%
3	Students collect data through discussion	4	4	4	4	3	3,8	95%
4	Students present the data obtained at the LKM	4	3	4	4	4	3,8	95%
5	Students analyze the data obtained at the LKM	4	4	4	3	4	3,8	95%
6	Students present the results of the discussion	3	4	4	4	4	3,8	95%
7	Students took the pre test and post test enthusiastically	3	4	4	4	4	3,8	95%
III. CLOSING								
1	Students can make conclusions from learning activities	4	4	4	4	4	4	100%
Total Aspect Score							38,8	
Total Average Score of All Aspects							3,88	
Percentage of Overall Aspects								97%

Student response questionnaire sheets were filled out by 23 students. The student response scores were then recapitulated and analyzed. Overall the average percentage of each question answered "yes" was 93% and answered "no" was 7%. So, it can be concluded that the device developed based on the results of the student response questionnaire meets the criteria, which is very high.

Table 5. Response Results

No.	Responded aspect	Evaluation		Percentage	
		Yes	Not	Yes	Not
1	**Did you enjoy the following learning components:**				
	Learning materials in	22	1	96%	4%
	Student worksheets (LKM)	23	0	100%	0%
	Learning atmosphere	22	1	96%	4%
	How to teach				
2	**Are the following learning components new?**				
	Learning materials in	23	0	100%	0%
	Student worksheets (LKM)	21	2	91%	9%
	Learning atmosphere	16	7	70%	30%
	How to teach	21	2	91%	9%
3	Are you interested in following this lesson?				

4	**Can you clearly understand the language used in:**				
	Student worksheets (LKM)	22	1	96%	4%
	Final research test question sheet				
5	**Can you understand the meaning of each question/problem presented in:**				
	Student worksheets (LKM)	19	4	83%	17%
	Final research test question sheet	20	3	87%	13%
6	**Are you interested in the appearance (writing, pictures, and the location of the pictures) on:**				
	Student worksheets (LKM)	23	0	100%	0%
	Final research test question sheet	23	0	100%	0%
7	**Do you like discussing with group members to solve problems by exchanging answers?**	22	1	96%	4%
Average		21,3076	1,6923	93%	7%

The results of the answers collected by students obtained a number of 19 students getting scores above 60, this means that 83% of students have completed and have met one of the criteria for a device to be called effective. So, it can be concluded that the developed device is effective.

Normality test

The results of the normality test from the posttest data in the experimental and control classes are$p\ .\ value$ = 0.06. If $p.\ value$> 0.06, then the data is normally distributed. The p. value significance value is 0.06 > 0.05, it can be concluded that the posttest data from the two classes are normally distributed.

statistic	p.value	method	data.name
0.95	0.06	Shapiro-Wilk normality test	datasetInput()[, input$var.y]
0.95	0.06	Shapiro-Wilk normality test	datasetInput()[, input$var.y]

Figure 4. Normality Test Results

Homogeneity Test

The results of the homogeneity test from the posttest data in the experimental and control classes are $p\ .\ value$ = 0.7413. If $p\ .\ value$> 0.05, then the data is homogeneous. The significance value of p. value is 0.7413 > 0.05, it can be concluded that the posttest data from the two classes are homogeneous.

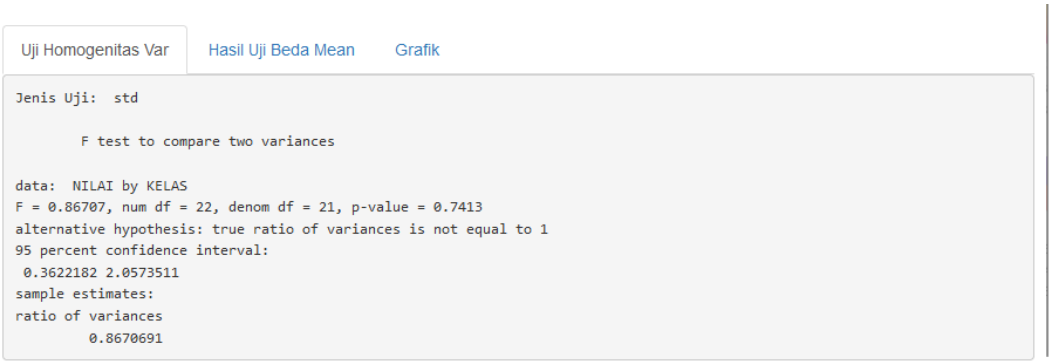

Figure 5. Homogeneity Test Results

Two Free Samples T-Test

The results of the t test for two independent samples from the *posttest* data in the experimental and control classes are$p$. $value$ = 0.03005. If p. $value$ < 0.05, then H_0 rejected. The significance value of *p.value* is 0.03005 < 0.05, it can be concluded that the *posttest* data from the two classes show that there is a significant difference in scores between the results of students in the control class and the experimental class.

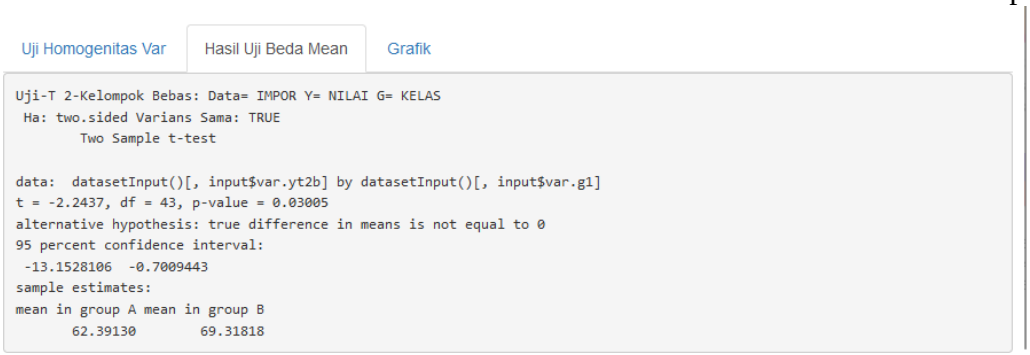

Figure 6. t-Test Results of Two Free Samples

DISCUSSION

The result of this study shows that research based learning materials with a developed STEM approach meet valid, practical, and effective criteria, and which is in agreement with on the results of previousre search conducted by Asy'ari (2022) entitled "Development of Research-Based Learning Devices with a STEM Approach in Improving Student Generalization Thinking Skills in Solving Graceful Coloring Problems". The device that has been developed is carried out a validation process by two validators. The validation results show that this learning device is included in the valid category, explanation which shows that a learning device is said to be valid if it meets 75 <score< 90 and is very valid if it meets 91 <score< 100 (Hobri, 2021). In addition, these learning material shave also met the criteria for learning materials to be called practical and affective.

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 class room will result in the 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), explained that learning carried out in conventional classes causes students to tend to be passive and lack the impetus to develop their potensial.

CONCLUSION

The results of developing research-based learning materials in with the STEM approach after testing the materials in and analyzing them, it can be concluded that the materials in meet the valid, practical, and effective criteria. As well as the results of the study on the t-test of two independent samples from the posttest scores, it was found that there were significant differences in the experimental class from the use of research-based learning materials in with the STEM approach to students' generalization skills in solving local vertex irregular reflexive coloring problems.

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