



## **Analysis of the Implementation of Research-Based Learning Material with STEM Approach in Improving Students' Metacognitive Skill**

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The purpose of this study (a) to determine the effect of RBL STEM learning material in improving the student metacognitive skill (b) to analyse the student phase portrait of their metacognitive skill in solving the problem of cascara herbal tea making. This type of research is a quasi-experimental group with one group pretest posttest design. The research subjects were 160 students in the 5th semester of the 2021/2022 academic year at the Jember State Polytechnic, Indonesia. The instrument used was a description test which was assessed using the rubric of metacognitive skill and metacognitive awareness inventory. Data were analyzed based on parametric statistical calculations. The indicators of metacognitive skill in problem solving used are planning, monitoring and evaluation. The results showed that RBL with the STEM approach affected metacognitive skill in overcoming the problem of using cascara as an herbal tea. The results of the correlation analysis showed an R of 0.286, so that the acquisition of linear regression  $Y = 52.135 + 0.286 X$ . From this equation it can be seen that for every 1-point increase in the item -improvement skills score, there is an increase in metacognitive skill of 52.135.

**Keywords:** research based learning, metacognitive, utilizing cascara, STEM, learning

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## INTRODUCTION

The implementation of research-based learning materials with a STEM (Science, Technology, Engineering, and Mathematics) approach can have a positive effect on students' metacognitive skills in solving problems related to the use of cascara for herbal tea. The STEM approach in education emphasizes direct problem-based learning, that assist students in developing critical thinking and problem-solving skills (Arief, 2013). In this research, students engage in research projects to explore the use of cascara for herb tea, including its history, cultivation, processing, and benefits. By conducting research, students can develop their metacognitive skills through reflecting on their own thinking and learning processes (Christopoulos, 1987). Students, for example, can examine their assumptions, evaluate evidence, and consider alternative perspectives. These skills are essential for success in the STEM field and in solving real-world problems. In addition, the use of cascara for herbal tea provides a relevant and engaging context for students to develop STEM skills and knowledge. They can deepen their understanding of botany, biology, and chemistry by studying the science behind herb tea (Hutasoit, 2021). Students can also apply engineering concepts when designing experiments to test the effectiveness of cascara tea (Nafisa, 2018). Overall, the application of research-based learning materials with a STEM approach is an effective way to enhance students' metacognitive skills and comprehension of STEM concepts (Nugroho, 2019).

By incorporating a STEM approach, students are exposed to inquiry-based and hands-on learning activities that encourage them to think critically and creatively (Suryati, 2021). The focus on the use of cascara for herb tea yields students real-world problems to solve and encourages them to employ their scientific knowledge to find solutions (Sholichah, 2019). The use of metacognitive strategies, such as reflection and self-assessment, helps students become more conscious of their own learning process and understand how they can improve their problem-solving skills. This, in turn, can enhance their metacognitive skills and contribute to a deeper understanding of the subject matter (Galanakis, 2017). In addition, the research-based learning material grants students access to the latest knowledge and advances in the field of herb tea production, which can help them stay captivated and inspired. The purpose of applying research-based learning materials with a STEM approach is to offer students with an in-depth and captivating learning experience that serves to enhance their metacognitive skills and their understanding of the use of cascara for herb tea (Susanti, 2021).

It is crucial to note that the implementation of research-based learning materials with the STEM approach must be carefully planned and well-structured to be most effective (Nunaki, 2019). This include combining a variety of educational methods, such as group work, individual tasks, and hands-on activities, to engage students and encourage critical thinking. The implementation of research-based learning materials with a STEM approach potentially improves students' metacognitive skills considerably in solving problems related to the use of cascara for herb tea. This form of teaching can nurture critical thinking and problem-solving skills that are essential for success in a rapidly changing world (Becker, 2011).

Research-based learning materials (RBLs) that leverage STEM approaches (Science, Technology, Engineering, Mathematics) can be an effective way to enhance students' metacognitive skills, including the use of cascara for herb tea. The STEM approach emphasizes active learning and immediate problem-solving that help students develop critical thinking and metacognitive skills (Global, 2014).

The STEM approach in the context of using cascara for herb tea involves students with researching the properties and benefits of cascara, including potential health benefits and potential side effects, designing and conducting experiments to determine the optimal conditions for extracting active compounds from cascara and making tea herbs, analyzing data and drawing conclusions about the best methods of making herb tea using cascara and reflecting their own thinking processes and learning strategies during the process, evaluating their understanding and problem-solving skills. By combining RBLs material with the STEM approach, students develop a deeper understanding of the subject matter and enhance their metacognitive skills as they engage in active learning and problem-solving. In addition, by reflecting on their own thinking processes, students can better understand their strengths and weaknesses and adjust their learning strategies (English, 2015).

Application of research-based learning materials with STEM (Science, Technology, Engineering, and Mathematics) approaches have a positive impact on student metacognitive skills, in problem-solving tasks (Lukitasari, 2021). STEM education is designed to encourage critical thinking, creativity, and problem-solving skills (Suratno, 2019). Using real-world problems and practical activities assists students to develop these skills by encouraging them to think thoroughly about problems and how to solve them. In the context of using cascara for herb tea, combining the STEM approach can involve students undertaking research on the properties and benefits of cascara, designing and conducting experiments to test cascara's use in herb tea as well as analyzing the results (Murlida, 2021 ). This process requires students to think critically about problems and use their metacognitive skills to plan, monitor, and evaluate their own learning. By engaging in this type of learning, students can develop their metacognitive skills, which are essential for success in both academic and real-world situations. Through the process of conducting research, designing experiments, and analyzing data, students can learn to think critically about problems, generate new ideas and approaches, and evaluate the effectiveness of their own solutions (Okpara, 2007).

The implementation of research-based learning materials with the STEM (Science, Technology, Engineering, and Mathematics) approach can be a valuable aid in improving student metacognitive skills in finishing the use of cascara for herb tea. The STEM approach emphasizes hands-on learning, critical thinking, and problem-solving that are essential aspects of metacognition. When students engage in research-based learning activities with a STEM approach, they are encouraged to think critically about the information presented to them and apply their knowledge to real-world problems. This can help students to develop their metacognitive skills, as they become more mindful of their own thinking processes and able to reflect on how they came to certain solutions (Han, 2015). Based on the observations made by researchers, there is a

problem that requires a solution, namely coffee production which produces a lot of waste. Based on observations there have been no innovations in the use of cascara which has high economic value, some of the abundant cascara is used by breeders as animal feed and the rest is sold (Komaria, 2020). Students, as the next generation who are rich in knowledge, always develop innovative cash utilization so that this commodity continues to grow.

**METHOD**

**The Focus of the Study**

The study focused on the interaction of metacognitive skills in students under the implementation of research based learning model with STEM education on utilization cascara. The research subjects of this study were students of the 5th semester of the academic year 2021/2022 at Politeknik Negeri Jember, Indonesia. The study was conducted over five weeks using fermented cascara material with magnetic fields of different intensities to make healthy herb tea.

**Samples**

In the research, 160 students from two study programs at Politeknik Negeri Jember participated. The determination of the sample size was based on the Slovin formula with a 5% margin of error, which is [sample = population x e<sup>2</sup>]. Three criteria must be met for the selection of samples: high, medium, and low capacity. High, medium and low are the level of student ability. High ability students if 80 ≤ score obtained ≤ 100. Students with medium ability if 60 ≤ score obtained < 80. Students with low ability if 0 ≤ score obtained < 60. This criterion is used for the selection of sample selection in order to obtain the ability of the sample evenly. The high, low and medium categories are for the portrait phase only. This category was created by researchers following university guidelines. The choice of campus was determined by the availability of study programs and the suitability of the material for the mathematics being taught. The selected campus was Politeknik Negeri Jember particularly food industry engineering using three classes, namely classes A, B, and C. Each class received the same treatment and employed the same test indicators.

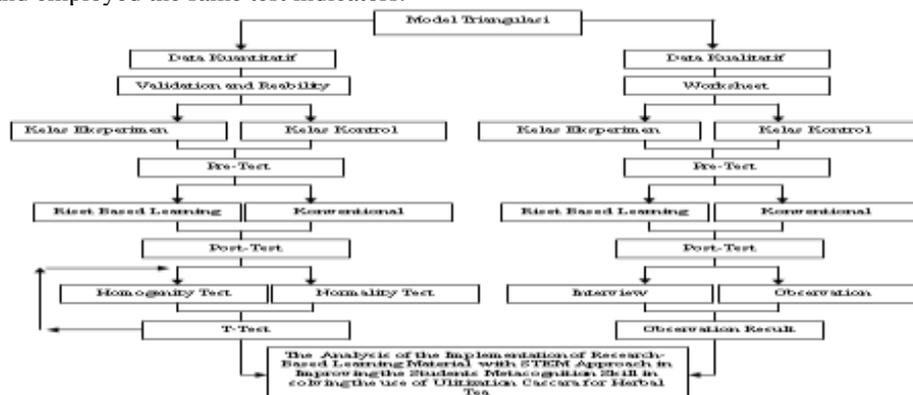


Figure 1  
Data collection method

### Instruments and Procedure

This research is a mixed method research. It combined two forms of research: experimental research and development research. The research instruments used were the essay tests developed by the researchers and the metacognitive skills developed by Schraw, applied to all samples. The application of research learning models with STEM approaches in the learning process used syllabi, semester study plan, lesson plans, students' worksheets, a pretest and a posttest. To make it clearer, look at Figure 1.

### Data Analysis

The analysis of the students' answers in terms of metacognitive skill for each dimension consisted of (1) declarative knowledge, (2) procedural knowledge, (3) conditional knowledge, (4) planning, (5) information management strategies, (6) comprehension monitoring, (7) debugging strategies, and (8) evaluation. The questionnaire results were tabulated according to the alternative choices, namely "always" was assigned 5 points, "very often" was assigned 4 points, "often" was assigned 3 points, "rare" was assigned 2 points, "very rare" was assigned 1 point and "never" was assigned 0 point. The points obtained were converted to a scale of 0-100. The level of metacognitive skill was categorized using rating scale from Green (2002) consisting of super ( $85 \leq x < 100$ ), good ( $68 \leq x < 85$ ), developing ( $51 \leq x < 68$ ), less capable ( $34 \leq x < 51$ ), at risk ( $17 \leq x < 34$ ), and not yet developed ( $0 \leq x < 17$ ). The analysis of metacognitive skills before and after the research-based learning model was carried out using scores obtained on pretests and post-tests using Pearson Correlation; the scores met the normality assumptions or using Spearman Rank Correlations as non-parametric statistics. A regression analysis was performed to predict the relationship patterns. The data was analyzed using the SPSS for Windows Release 23.0 program. The following chart is presented to give a clearer design of this study.

### Student Task



Figure 2  
Cascara waste in coffee plantations

Based on Figure 2, to improve metacognitive skills with indicators of planning, monitoring and evaluating, please answer the following question correctly. Question for indicator of planning, explain your opinion, why is it necessary to carry out further processing on cascara? Questions for indicator of monitoring, in the field in reality, cascara is simply discarded without processing. It is also sold to buyers at the price of Rp 200/kg. Also, cascara can be processed into fertilizer. In your opinion, what is better action to cascara? Question for the indicator of evaluating, what is used for any cascara all this time? Sort by economic value from low to high!

### FINDINGS

This study aims examine the interaction between metacognitive skills and students' problem-solving skills in solving the problem of using cascara for healthy herb tea. A summary of the average score results on each measurement indicator against student metacognitive skills in solving the problem of cascara utilization is presented in Table 1.

Table 1  
Recapitulating average scores of students' metacognitive skills in solving problems of cascara use before and after classes

Variable		Average $\pm$ std. deviation	Category
Declarative Knowledge	Pre-Test	72,10 $\pm$ 12,59	Good
	Post-Test	72,9 $\pm$ 14,72	Good
Procedural Knowledge	Pre-Test	74,78 $\pm$ 12,55	Good
	Post-Test	69,37 $\pm$ 15,84	Good
Conditional Knowledge	Pre-Test	69,92 $\pm$ 12,19	Good
	Post-Test	67,75 $\pm$ 16,32	Developing
Planning	Pre-Test	74,86 $\pm$ 14,05	Good
	Post-Test	74,22 $\pm$ 14,07	Good
Information Management Strategies (IMS)	Pre-Test	72,11 $\pm$ 14,76	Good
	Post-Test	76,07 $\pm$ 12,41	Good
Comprehension Monitoring (CM)	Pre-Test	69,05 $\pm$ 14,35	Good
	Post-Test	73,25 $\pm$ 12,96	Good
Debugging Strategies(DS)	Pre-Test	71,98 $\pm$ 14,59	Good
	Post-Test	69,02 $\pm$ 14,79	Good
Evaluation	Pre-Test	75,10 $\pm$ 13,36	Good
	Post-Test	75,37 $\pm$ 13,26	Good
Average $\pm$ std. deviation	Pre-Test	72,49 $\pm$ 6,38	Good
	Post-Test	72,24 $\pm$ 7,96	Good

Almost all variables are in the good category with a slight range of scores. Conditional knowledge is the only variable on developing category with an average of 67.75 and a standard deviation of 16.32. The average pre-test score was 72.49 with a standard deviation of 6.38 and the post-test average of 72.24 with the standard deviance of 7.96. Both scores are in the good category. These values indicate that some students have good metacognitive skills, but they need to be developed to maximize. The percentage results of metacognitive skill levels can be seen in diagram 2.

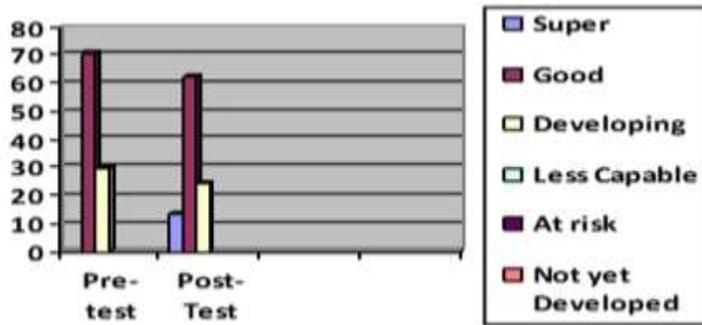


Diagram 1  
Percentage level of the metacognitive skills

Based on Diagram 1, 113 students (70.62%) were in a good category and 47 students (29.37%) were in the developing category. Different results were obtained on the post-test. There were a total of 21 students (13.1%) in the super category, 100 students in the good category, and 39 in the developing category. At the time of the pre-test or post-test, there are not any students who fell into the category of being less capable, at risk, or not yet developed. Table 2 depicts the metacognitive and problem-solving profiles of students using a research-based learning model and a STEM-based approach to solve problems involving the use of cascara for healthy herb.

Table 2  
Number of samples, mean, std. deviation, min and max scores of students' metacognitive skills and problem-solving skills in solving problems of cascara use

		N	Minimum	Maximum	Mean	Std. Deviation
Metacognitive skills	Pre-Test	160	56	84	72.49	6.384
	Post-Test	160	56	91	72.25	7.966
Problem-solving skills	Pre-Test	160	49	88	69.10	8.080
	Post-Test	160	50	90	70.27	8.802
Valid N (listwise)		160				

The mean of pre-test and post-test of metacognitive skills acquired are 72.49 and 72.25, while mean pre-test and after-test of the problem-solving skills are 69.10 and 70.27. The pre-test and post-test std.deviation values for metacognitive skills were 6,384 and 7,966 while the pre-test and Post-test problem-solving skills were 8,080 and 8,802. The maximum values of pre-test and post-test metacognitive skills are 84 and 91, while the minimum values for pre-test and post test metacognitive skills are 56 and 56. The average score of metacognitive skills of both, as well as the problem-solving skills score is in the high category.

The interaction of metacognitive skills and problem-solving skills was further analyzed using correlation analysis and continued with regression analysis to predict patterns of interaction. The correlation of pre-learning outcomes with research-based learning models with STEM approaches between metacognitive skills and problem-solving skills is shown in Table 3.

Table 3

Correlation scores before learning using a research-based learning model with a STEM approach between metacognitive skills and problem-solving skills

		Metacognitive Skills	Problem-solving skills
Metacognitive Skills	Pearson Correlation	1	,481**
	Sign. (2-tailed)		,000
	N	160	160
Problem-solving skills	Pearson Correlation	,481**	1
	Sign. (2-tailed)	,000	
	N	160	160

The results of the correlation analysis before learning with the research-based learning model with the STEM approach showed that metacognitive skills and problem-solving skills had a value of 0.481 which indicates that there is a strong relationship between metacognitive skills and troubleshooting skills. The correlation result has a significance value of 0,000 which means that the correlations result is very significant. Post-learning correlations with research-based learning models with STEM approaches between metacognitive skills and problem-solving skills are shown in Table 4.

Table 4

Correlation scores after learning using a research-based learning model with a STEM approach between metacognitive skills and problem-solving skills

		Metacognitive skills	Problem-solving skills
Metacognitive skills	Pearson Correlation	1	,316**
	Sign. (2-tailed)		,000
	N	160	160
Problem-solving skills	Pearson Correlation	,316**	1
	Sign. (2-tailed)	,000	
	N	160	160

The correlation analysis results showed that metacognitive skills and problem-solving skills had a value of 0.316 which indicates that there is a strong relationship between metacognitive skills and troubleshooting skills. The correlation result has a significance value of 0,000 which means that the correlations result is very significant. The results of the correlation analysis are followed by the regression analysis seen in Table 5.

Table 5

Results of regression test analysis before learning using research-based learning model with stem approach

Model	R	R square	Adjusted R Square	Std. Error of the Estimate
1	,481	,231	,226	5,616

The results of regression test analysis before learning with a research-based learning model with a STEM approach showed a R value of 0.481 with a R2 value of 0,481. This value represents the relative contribution of metacognitive skills to problem-solving skills of 48.1%. Thus, the development of student metacognitive skills was contributed by problem-solving mastery of 48.1%. Results of post-blasting regression analysis with research-based learning models with STEM approaches are shown in Table 6.

Table 6

Results of regression test analysis after learning using research-based learning model with stem approach

Model	R	R square	Adjusted R Square	Std. Error of the Estimate
1	,316	,100	,094	7,581

The regression test results showed a R value of 0.316 with a R<sup>2</sup> value of 0,993. This score represents a 31.6% relative contribution of metacognitive skills to problem-solving skills. Thus, the development of student metacognitive skills was contributed by problem-solving mastery of 31.6%. The significance of regression between metacognitive skills and problem-solving skills before using a research-based learning model with a STEM approach was performed with the ANOVA test shown in Table 7.

Table 7

Results of ANOVA test before learning using research-based learning model with stem approach

Model		Sum of Square	Df	Mean Square	F	Sig.
1	Regression	1497,497	1	1497,497	47,483	,000
	Residual	4982,890	158	31,538		
	Total	6480,476	159			

The significance of the regression equation between metacognitive skills and problem-solving skills is 0,000. This value is less than 0.05, so it can be concluded that the equation of regression between meta-cognition skills and problem-solving skills is significant. The significance of regression between metacognitive skills and problem-solving skills after using a research-based learning model with the STEM approach was performed with the ANOVA test shown in Table 8.

Table 8

Results of ANOVA test after learning using research-based learning model with stem approach

Model		Sum of Square	df	Mean Square	F	Sig.
1	Regression	1009.226	1	1009.226	17.561	,000
	Residual	9080.164	158	57.469		
	Total	10089.390	159			

The significance of the regression equation between metacognitive skills and problem-solving skills is 0,000. This value is less than 0.05. Thus, it is concluded that the equation of regression between meta-cognition skills and problem-solving skills is significant. Furthermore, the equation of before learning regression lines with the research-based learning model with the STEM approach was analyzed and shown in Table 9.

Table 9

Linear regression equation before learning using research-based learning models with STEM approach

Model		Unstandarized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error			
1	(Constant)	46.247	3.835		12.060	,000
	Problem-solving skills	,380	,055	,481	6.891	,000

The result of the linear regression equation has a constant value of 46,247 and a coefficient value of 0,380, so that the linear regression equation of  $Y = 46.247 + 0.380 X$  is obtained. Through this equation, it can be seen that for every 1 point increase in problem-solving skills score, there is an increase of 46,247 in metacognitive skills. Analysis of post-learning regression line equations with research-based learning models with STEM approaches shown in Table 10.

Table 10

Linear regression equation after learning using research-based learning models with STEM approach

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig	
	B	Std. Error	Beta			
1	(Constant)	52.135	4.837		2,512	,013
	Problem-solving skills	,286	,068	,316	27,728	,000

The result of the linear regression equation has a constant value of 52.135 and a coefficient value of 0.286, thus obtaining the linear regression equation of  $Y = 52.135 + 0.286 X$ . Through this equation, it is seen that for every 1 point increase in the problem-solving skill score, there is a 52.135 increase in metacognitive skills.

1	Exposure Stage	b	Conducting research according to students' worksheets and discussions
a	Planning for understanding the problems	c	Analyzing the findings
b	Searching for references from various sources	d	Self-evaluating whether there is an easier way to work on research innovations done
c	Understanding the articles	e	Conducting the research properly
d	Asking questions	3	Capstone Stage
e	Thinking of several ways to solve a problem in cascara	a	Presenting the discussion results
f	Reading carefully using appropriate time	b	Responding
g	Evaluating the methods used in solving problems	c	Collecting students' worksheets
h	Drawing conclusions to plan the solution	d	Evaluating research paths
2	Experience Stage	e	Drawing conclusions
a	Designing their own research examples to make the findings more meaningful		

Based on the data described, the learning steps using the research-based learning model with the STEM approach began with the following steps: exposure step, experience step and capstone step. In each meeting, before the learning ends, the students were also assigned to fill out student worksheets to learn about the metacognitive skills and problem-solving skills that are interconnected between the one meeting and the next. In addition, at the beginning and end of the meeting, students were also given an inventory of metacognitive skills to get used to developing the skills they have. The structure of the study presented a phase portrait in the following Figure 3.

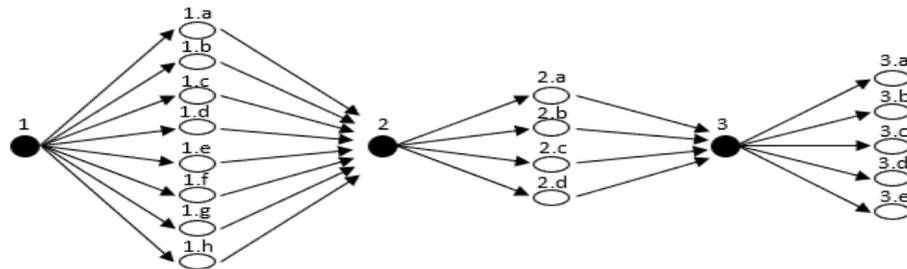


Figure 3  
General phase potrait research based learning with a STEM approach

Based on the picture above, several phases of the students' thinking skills consist of several steps. Each phase of student thinking has two circles, namely a black circle that depicts research-based learning syntax with a STEM approach and a white circle describes research-driven learning syntactic with STEM methods, whereas a white box is an indicator of metacognitive skills in solving cascara utilization problems.

From the research, it is revealed that student scores during the post-test are greater than the pretest. Increased learning outcomes appeared as a result of implementing research-based learning models with the STEM approach which is interdisciplinary that can help students understand in depth any material related to science, technology, engineering and mathematics. This triggers the development of metacognitive and problem solving skills. Metacognitive activity occurs when students consciously adjust and manage their thinking strategies when solving problems and thinking about a goal. The description of the indicators in metacognitive is expected to be able to integrate new ideas with existing knowledge and construct an understanding so that it can present sequences and steps in assembling and doing a job or knowledge about how to use what is known in solving problems. Metacognitive skills have an influence on motivation, academic achievement and quality of learning, thus they are essential in improving students' self-quality. The following are examples of student work in various categories.

**Subject 1**

Metacognitive skills with the *Ok* category and problem solving skills with the good category.

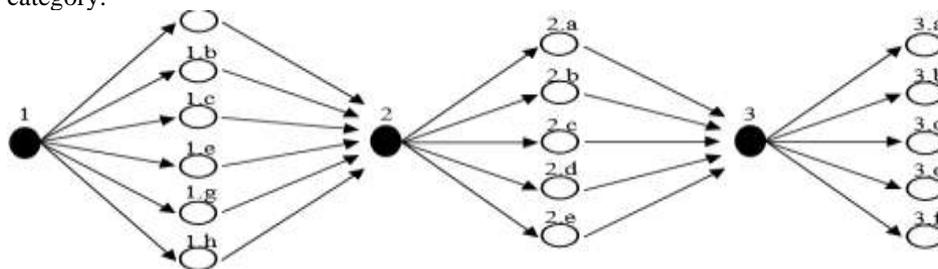


Figure 4  
Phase potrait research based learning with a STEM approach in metacognitive skills with the *Ok* category and problem solving skills with the good category.

The results of student worksheets regarding the use of cascara:

1. Cascara also makes profits that are no less large than just harvesting the coffee beans. If left unchecked, cascara will become waste. Therefore, it is necessary to do further processing on cascara. The content of cascara such as protein, caffeine, and phenolic compounds in the form of chlorogenic acid is very beneficial for health. This is an opportunity for further cascara processing.
2. Coffee skin waste should be processed into fertilizer and tea. Making fertilizer from coffee skin is time consuming and the process is quite complicated, whereas if it is processed into tea the process is quite simple. Select according to your needs and conditions as all of them have equally high selling value.
3. The sequences are :
  - a. Thrown away, this does not add economic value
  - b. Used as fertilizer, this only reduces expenses for coffee maintenance
  - c. Used as animal feed, it can increase income from raising livestock
  - d. Used as tea, this can add economic value, production costs are also low.

In the metacognitive skills of students in the *Good* category, they have coherent thoughts. This can be seen from the analysis of the answers given, starting from general knowledge about cascara waste, selling value of cascara, cascara content and further processing of cascara products. Furthermore, students choose wisely the cascara processing model based on the results of their own analysis so that they can sort the economic value of cascara from low to high.

Students in this category can think about things that really need to be learned before doing assignments by looking for references from supporting articles. They can think of several ways to solve a problem and choose the best one, reading orders carefully to completing assignments on time. When connected with the problem-solving skills they have, this type of student is able to develop plans to solve problems and express their opinions.

After observing the results of student work, the researcher conducted an interview with subject 1 below:

Reseracher (R) : What do you think about the use of cascara?

Subject 1 (S1): Moderate, although some require high analysis but it is still easy.

R : Are you interested in finding or reading articles provided by researchers regarding several plans to use cascara?

S 1 : Yes, although to know further processing or utilization of cascara, I have to read many articles that require more thorough analysis.

R : Do you have difficulty identifying and formulating problems based on the literature and research experience that you have to conduct research?

S1 : No, as I'm used to searching literature, then identifying problems that need solutions. Armed with the experience that I have, research can get maximum results.

R : Do you have difficulty conveying ideas or research plans in providing solutions to problems with measurement or computational methods?

S1 : Definitely, I had to learn a lot as I was not used to designing research without expert assistance.

**Subject 2**

Metacognitive skills with the *development* category and problem solving skills with the *sufficient* category

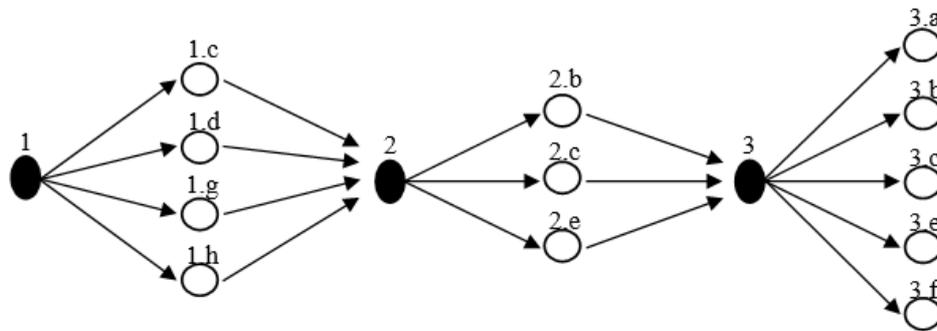


Figure 5

Phase portrait research based learning with a STEM approach in metacognitive skills with the *development* category and problem solving skills with the *sufficient* category.

The answers of students in this category are slightly different. The following are the answers for each number that have been described:

1. Good processing can produce functional products that can be traded. In addition, clean production of cascara waste can improve the environment by reducing pollutants.
2. It is better to process it into fertilizer or tea in order to increase the selling value of cascara which is usually considered as waste. It can also be used as a food additive in the form of cascara flour.
3. Fertilizer (without processing), fertilizer (with processing), cascara tea, and cascara flour

Students in this category have different answers from subject 1. Students give general plans and do not analyze answers based on their understanding of a specific product by reviewing existing literature. Students in this category need support from facilitators and colleagues so that they are motivated to innovate in their learning. They are less able to think about what is needed to answer questions properly, less able to consider

several alternative answers to a problem that requires resolution. Following are the results of interviews between researchers (R) and Subject 2 (S2).

R : Are you enthusiastic when lecturers teach using a research-based learning model with a STEM approach?

S2 : Yes, because the research-based learning model with the STEM approach is unfamiliar and new to me

R : When learning by doing research, can you complete it?

S2 : Yes, I can do it but I have to follow the lecturer's instructions. I find it difficult when given the task of innovating cascara

R : What do you do when the lecturer gives instructions to do research?

S2 : I listened to the lecturer's explanation, then saw what other fellow students were doing.

R : Do you evaluate the research results that you have chosen?

S2 : I do, I evaluate the results of my choices but I do not innovate many answers as I'm not interested in reading a lot of articles.

### Subject 3

Metacognitive skills with the *cannot really* category and problem solving skills with the *lacking* category

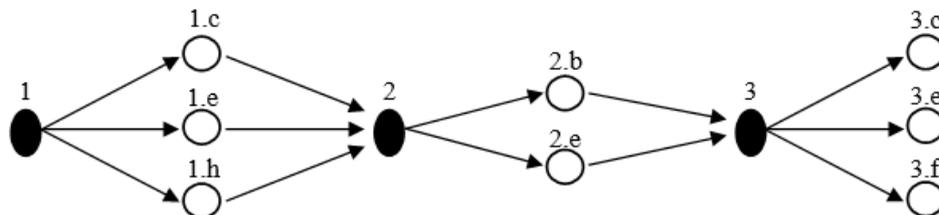


Figure 6

Phase portrait research based learning with a STEM approach in metacognitive skills with the *cannot really* category and problem solving skills with the *lacking* category

The results of the Subject 3 test questions on student worksheets regarding the use of cascara.

1. Because it may cause the environment
2. Developed, as it can add to the sale value as well, since coffee skins are included as waste that has no selling value
3. Animal feed, tea

The results of the interview are different from the previous subject. In metacognitive with the *cannot really* category, they find it more difficult to solve learning problems.

Students in this category are less able to map how to think and understand what they think. The work is less than optimal because they cannot monitor its own learning.

Based on observations during research, students of this type tend to be preoccupied with their own world, they chat with their mates, they are not careful in doing assignments, and do not read literature from existing journals. Related to problem solving skills, the ability to understand problems and plan for solving problems is not good. The answers given were limited to general knowledge without answers based on the literature they had read so that the answers were less interesting and there were no innovative answers that fit the demands of the times. Student answers can be seen from the results of interviews with researchers.

- Peneliti (R) : Do you find any difficulties in solving problems?  
 Subject 3 (S3) : Yes, I do.  
 R : Can you explain why further processing is needed on cascara?  
 S3 : Cascara may cause pollution.  
 R : Why do you think cascara pollutes the environment? What substances does it contain?  
 S3 : I don't know, I just saw the picture but didn't read the article further  
 R : In working on the questions, did you read the summary on the previous sheet many times?  
 S3 : No, I only skimmed through it.

## DISCUSSION

The application of research-based learning materials with a STEM (Science, Technology, Engineering, and Mathematics) approach can have a positive impact on students' metacognitive skills when solving problems related to the use of cascara for herbal teas. Incorporating STEM activities in the classroom provides students with hands-on experiences that help develop critical thinking and problem-solving skills. When students are actively involved in conducting experiments, analyzing data, and making connections between concepts, they develop a deeper understanding of the material and are more likely to retain information (Breiner, 2012).

When it comes to using cascara for herbal teas, a STEM approach can help students understand the science behind the extraction process, the technologies involved in tea production, and the engineering principles used in designing equipment and machinery. By using a research-based approach, students can also explore the various applications and benefits of cascara tea and its impact on human health. By engaging in the activity, students can develop their metacognitive skills, including the ability to reflect on their own learning and understanding, monitor their own progress, and identify areas where they need additional support. Self-awareness and self-monitoring are important components of effective problem solving and critical thinking (Komaria, 2022).

Overall, the application of research-based learning materials with a STEM approach has the potential to significantly improve students' metacognitive skills when solving problems related to the use of cascara for herbal teas. By providing students with

opportunities to engage in inquiry-based learning experiences, they will be better equipped to develop their critical thinking and problem solving skills and to apply these skills to real-world situations (Humaizah, 2022). The application of research-based teaching materials with a STEM (Science, Technology, Engineering, Mathematics) approach can have a positive impact on developing students' metacognitive skills in solving problems related to the use of cascara for herbal teas (Muzaifa, 2022). Metacognitive is the ability to reflect on one's own thinking processes and to monitor and regulate one's own learning. The STEM approach that emphasizes direct inquiry-based learning can help students develop their metacognitive skills by encouraging them to think critically and solve problems systematically (Astuti, 2021).

In the context of using cascara for herbal teas, a research-based learning approach can help students develop their understanding of the properties and benefits of cascara as a natural remedy, as well as its potential drawbacks and limitations. By engaging in hands-on activities and experiments, students can develop their abilities to evaluate and interpret data, identify patterns and relationships, and draw conclusions based on their findings. In addition, the use of technology and data analysis tools can further enhance students' metacognitive skills by providing opportunities for them to reflect on and improve their problem-solving strategies. By using technology to visualize and analyze data, students can learn how to evaluate the accuracy and reliability of their results, and make informed decisions based on their findings. Overall, the application of research-based learning materials with a STEM approach can help students develop metacognitive skills and improve problem-solving skills related to the use of cascara for herbal teas. Cascara tea is not a new product, because it has been around for a long time (Giuliano, 2019).

Metacognitive refers to an individual's awareness and understanding of their own thought processes, and the ability to monitor and regulate their own learning. In solving problems related to the use of cascara for herbal teas, metacognitive skills are important because they allow individuals to reflect on their own thought processes and make adjustment to improve their problem-solving strategies. When using cascara for herbal teas, having strong metacognitive skills can help individuals evaluate the information they have gathered, identify key factors relevant to the problem, and determine the most appropriate approach to solving the problem. For example, they may consider the potential advantages and disadvantages of using cascara, as well as relevant scientific or medical information, to determine whether it is a safe and effective drug for their needs (Milawarni, 2021).

In addition, metacognitive skills can also help individuals evaluate the results of problem solving, and make adjustments as necessary to achieve the desired results. For example, if they find that their initial approach was not effective, they can reflect on what went wrong and make changes to improve their strategy. Metacognitive skills are important for solving problems related to the use of cascara for herbal teas because they involve the ability to reflect on one's own thinking processes and to monitor and regulate one's own learning. When students have strong metacognitive skills, they are better prepared to approach problem solving in a systematic and reflective manner (Azis, 2019).

To develop metacognitive skills in solving problems related to using cascara for herbal teas, students can engage in activities that encourage them to reflect on their own thought processes and evaluate their understanding of the problem. For example, they may be asked to:

1. Define the problem: What information do they need to address the problem of using cascara for herbal teas? What is their current understanding of the topic?
2. Plan their approach: How will they gather information and analyze data regarding the use of cascara for herbal teas? What tools and resources will they use?
3. Track their progress: How well are they progressing in their problem solving efforts? Are they staying on track with their plan?
4. Evaluate their results: What did they learn from their research and experiments with cascara for herbal teas? What new questions emerge from their findings?

By engaging in this reflective practice, students can develop their metacognitive skills and become more effective problem solvers. In addition, incorporating hands-on inquiry-based activities and technologies can further support the development of their metacognitive skills by providing opportunities for them to experiment and analyze data (Lee, 2016). Metacognitive skills are very important for solving problems related to the use of cascara for herbal teas. This skill involves being able to reflect on one's thought processes and problem solving, and to monitor and regulate one's own learning. When solving problems related to using cascara for herbal teas, individuals with strong metacognitive skills are able to:

1. Plan and organize their thinking and approach to problems.
2. Monitor their understanding of the problem and make adjustments as necessary.
3. Evaluate the accuracy and reliability of the information they use.
4. Reflect on their thought processes and make changes to improve their problem-solving strategies.
5. Draw conclusions based on the evidence they gather.

By developing their metacognitive skills, individuals can become more effective problem solvers and make more informed decisions regarding the use of cascara for herbal teas. In addition, the process of reflecting on one's own thoughts can help individuals develop a deeper understanding of problems and the information they use, resulting in more accurate and effective solutions (Rivas, 2022). When properly preserved, Cascara can be enjoyed as an herbal tea and is an ideal alternative source of caffeine for those who don't like the taste of coffee. If consumed properly, it provides health benefits, such as antioxidant properties so that it can be a useful food. However, not all fruit or coffee husks can be made cascara. Planning and care is required when preserving cherries to make cascara, thus potentially making it a premium specialty drink with various potential benefits (Zeckel, 2019).

## CONCLUSION

The innovation of using cascara into various kinds of products has not been widely used. One of the innovations made by students in research is by exposing cascara to a magnetic field to improve quality/taste. Innovations for using cascara need to be introduced early on so that the next generation is able to take the best steps in managing the potential in their environment so that this commodity continues to grow.

The application of research-based teaching materials with a STEM approach can be an effective way to improve students' metacognitive skills, especially in solving cascara problems for herbal teas. In the case of using cascara for herbal teas, students can be involved in hands-on activities that involve experimenting with various fermentation treatments to test the taste of cascara and see how it affects the taste and potency of the tea. The results showed that RBL with the STEM approach affected metacognitive skill in overcoming the problem of using cascara as an herbal tea. The results of the correlation analysis showed an R of 0.286, so that the acquisition of linear regression  $Y = 52.135 + 0.286 X$ . From this equation it can be seen that for every 1-point increase in the item -improvement skills score, there is an increase in metacognitive skill of 52.135.

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