RESEARCH ARTICLE

European Journal of Education and Pedagogy
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The Analysis of the Implementation of RBL-STEM in Improving Students Creative Thinking Skills in Solving the Use of Chitosan as an Antibacterial for Processed Meat

Rina S. D. Gita, Joko Waluyo, Dafik, and Indrawati

ABSTRACT

This study aims to identify students' creative thinking skills in solving the problem of using chitosan as a natural preservative in processed meat. This research uses mixed methods, namely a combination of quantitative and qualitative research methods. We used quantitative research methods to analyze the results of student's creative thinking skills in the application of RBL-STEM, while qualitative research methods were used to analyze the learning activities and portrait phases of students' creative thinking skills. The research respondents consisted of two classes, namely the control class and the experimental class. The control class has 25 students, and the experimental class has 30 students. We used tests, interviews, and questionnaires to collect data in this study. The results showed that the independent sample t-test on the post-test scores of the control class and the experimental class showed significant differences. This is due to the value of sig (2-tailed) is 0.000 (p=<0.05). It can be concluded that the application of the RBL learning model with the STEM approach can improve students' creative thinking skills in solving the problem of using chitosan as a natural preservative for processed meat. The rest, based on the results of observations on student learning activities, 98.25% of students in the experimental class lies in the "very active" category.

Keywords: chitosan, creative thinking skill, research-based learning, stem.

Published Online: March 7, 2023

ISSN: 2736-4534

DOI: 10.24018/ejedu.2023.4.2.524

R. S. D. Gita
Department of Postgraduate of Science Edu., University of Jember, Indonesia
(e-mail: gitarina16@gmail.com)
J. Waluyo
Department of Postgraduate of Math Edu., University of Jember, Indonesia
(e-mail: jokowaluyo.fkip@unej.ac.id)
Dafik*
Department of Postgraduate of Science Edu., University of Jember, Indonesia
(e-mail: d.dafik@unej.ac.id)
Indrawati
Department of Postgraduate of Science Edu., University of Jember, Indonesia
(e-mail: indrawatisutarto@gmail.com)

Corresponding Author

I. Introduction

Today's younger generation needs a lot of creative thinking skills (Yuliani *et al.*, 2018). People who will live in the twenty-first century must possess the four Cs (Creative thinking skill, Critical thinking skill, Communication skill, and Collaboration skill). Students' creative thinking skills can be measured under four aspects, namely Fluency, Flexibility, Originality, and Elaboration. The features and indicators of creative thinking skills are listed in Table I.

The four aspects above can be achieved effectively by students through the application of RBL learning with a STEM approach. RBL stands for Research-Based Learning, while STEM stands for Science, Technology, Engineering, and Mathematics. RBL is a learning model that brings research results and research open problems into the learning process (Suntusia *et al.*, 2019). Suggests that learning the RBL model can improve student learning outcomes, encourage the learning process, and encourage students to actively build their knowledge (Blackmore *et al.*, 2007). While STEM is a learning approach involving elements, namely science, technology, engineering, and mathematics in solving problems, especially problems that arise from real-life problems (Anderson *et al.*, 2001). The STEM problem on the use of chitosan as a natural preservative for processed meat was proposed (Gita *et al.*, 2021), see in Fig 1:

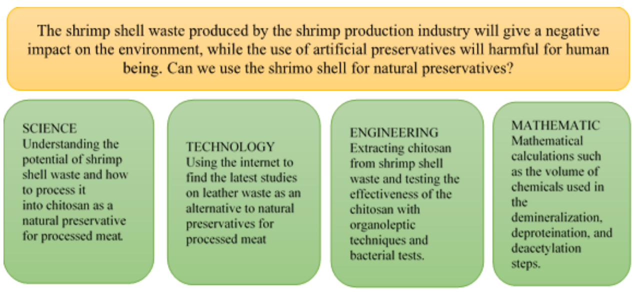


Fig. 1. The STEM problem in developing chitosan from shrimp shells as a natural preservative for processed meat.

While the use of RBL-STEM in the learning process for the use of chitosan as a natural preservative for processed meat has previously been discussed (Gita *et al.*, 2021).

The purpose of this study is to examine the RBL-STEM approach's application and determine its impact on students' creative thinking skills in addressing the issue of the use of chitosan as a natural preservative in processed beef see in Fig 2.

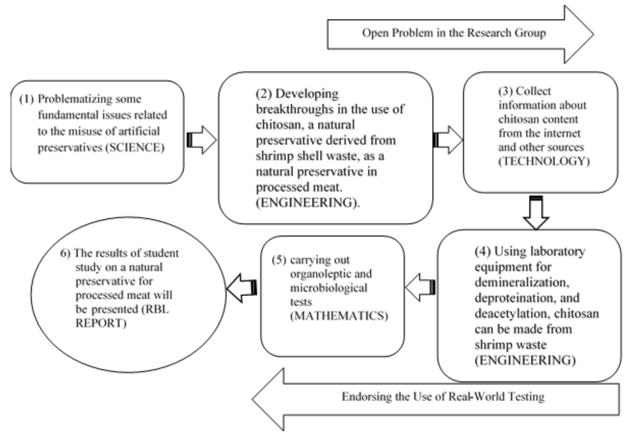


Fig. 2. RBL's framework in STEM education.

TABLE I: INDICATORS OF CREATIVE THINKING SKILLS

No	Aspect	Indicators
1.	*Fluency*	a. Students can explain the shrimp shell waste produced by the shrimp production industry which will have a negative impact on the environment. b. Students can describe how to break down the shrimp shell waste produced by the shrimp production industry, which will give a negative impact on human being health.
2.	*Flexibility*	a. The utilization of shrimp shell debris as a natural preservative for processed meat can be determined by students. b. Students can investigate whether shrimp shell waste, such as chitosan, can be converted into something more useful.
3.	*Originality*	a. Students can use the internet to look up information about chitosan as a natural preservative for processed meat, including its definition, raw materials, properties, and content. b. Students can learn about the function of chitosan as a natural preservative for processed meat by looking it up on the internet. c. Students can create a procedure for producing chitosan from shrimp shells by designing the steps.
4.	*Elaboration*	a. Students can prepare the tools and supplies that will be needed to make chitosan from shrimp shells. b. Students can make arguments on how to use organoleptic testing to determine the efficiency of chitosan as a natural preservative for processed meat. c. Students can create an organoleptic and microbiological test to determine the efficiency of chitosan as a natural preservative for processed meat.

II. METHOD

A. Research Design

This research is a mixed method, which is a combination of quantitative research approaches and qualitative research approaches. We use a non-equivalent control group design experimental research, which is done by using two classes that are given different treatments, the two classes are the experimental class and the control class. The nonequivalent control and experimental design can be seen in Table II below.

TABLE II: EXPERIMENTAL DESIGN NONEQUIVALENT CONTROL GROUP DESIGN

Class	Pre-test	Treatment	Post-test
Experimental	O1	With RBL-STEM Model Device	O2
Control	O3	-	O4

While the steps of carrying out the whole phase of the research can be depicted in the following chart see in Fig.3.

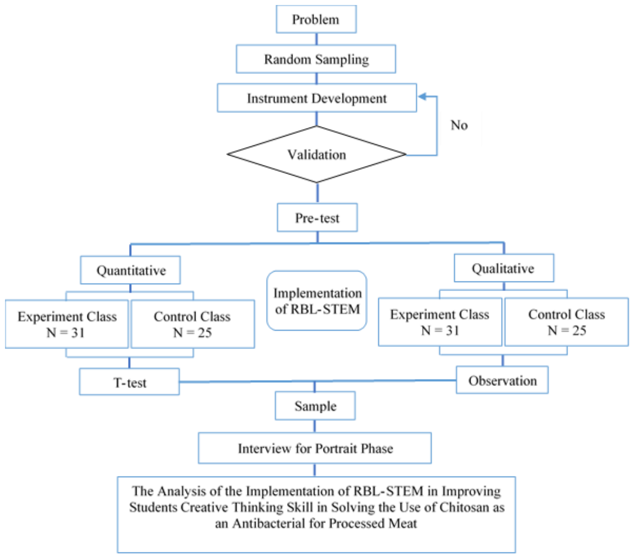


Fig. 3. The diagram of mixed method research.

B. Population

The population in this study is the Biology Education Study Program students. The research sample consisted of two classes, namely the control class with 25 students and the experimental class with 30 students. The quantitative method was used to analyze the student learning outcomes on their creative thinking skills, while the qualitative method was used to analyze the practicality of RBL-STEM learning materials and student learning activities. The research instrument used was a student learning outcome test (THBM) consisting of pre-test and post-test of 1–100 scale, and student learning activity observation sheets of 1–4 scale.

C. Subject Research Task

Students were assigned the challenge of synthesizing chitosan from shrimp shells and using it as a natural preservative in processed meat in this experiment. Students are responsible for carrying out the phases of chitosan production. Chitosan is made up of three stages: demineralization, deproteination, and deacetylation. Before the demineralization process is carried out, students wash the shrimp shells thoroughly; dry them under the sunshine or in the oven. After drying, the shrimp shells are mashed using a blender. The demineralization process was carried out by adding 1 N HCl with a ratio of 1:7 (w/v) by weighting the material and extractor volume (w/v) for 1 hour at 90°C. The reaction result was filtered using filter paper. The residue was dried in an oven at 65°C for 24 hours and weighed. In this process, students carry out deproteination steps which are carried out using a 3.5% NaOH solution by heating at 90°C for 1 hour. This is done as an alternative to deproteination with a ratio of dry shrimp waste and a solution of 1:10. At this stage, the protein from shrimp shell waste is separated by adding 100 grams of dried shrimp waste samples that have been cleaned and mashed in 1000 mL of 3.5 NaOH solution. % (w/v) and then heated at 90°C for 1 hour.

The neutral residue in the form of crude chitin was dried in an oven at 65oC for 24 hours and weighed. The next process of making chitosan is deacetylation, namely the process of removing the acetyl group (-COCH3) from chitin which is carried out using a 50% NaOH concentrated solution with a ratio of 1:20 (w/v) for 1 hour at a temperature of 120–140°C. The residue in the form of chitosan was washed with water until neutral and rinsed with distilled water. Chitosan was dried in an oven at a temperature of 65°C for 24 hours. After that, the finished chitosan is dissolved and used as a natural meat preservative. Organoleptic and microbiological tests were used to determine the efficiency of chitosan as a preservative for processed meat. The following includes information about shrimp shells, tools, and materials, as well as how to use chitosan see in Fig. 4.

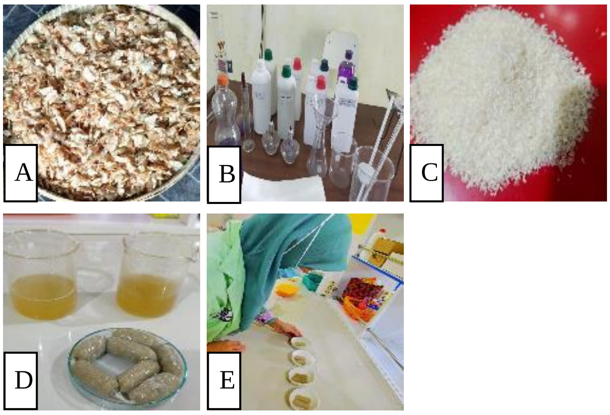


Fig. 4. Research Process (A. Shrimp shells, B. Tool and Materials, C. Chitosan, D. Application of chitosan, E. Observation).

III. Research Findings

This study uses quantitative data obtained from post-test scores in the control class and experimental class to be further analyzed by using an independent sample t-test with the help of the SPSS program. While the qualitative data obtained from the results of observations, questionnaires, and interviews were analyzed using descriptive analysis and phase portrait. To determine whether or not there is an effect of the implementation of the RBL-STEM model on students' creative thinking skills between the experimental class and the control class. The results of the THBM post-test were conducted by using the independent sample t-test, and it gives a significance value of 0.05 and a confidence level of 95%.

After conducting a validity and reliability test on the study instrument, the research on the experimental and control groups was conducted. Then, in both the experimental and control classrooms, students were given a pre-test to determine their starting capacity to think creatively, and the learning process was carried out in both. The learning process in the experimental class uses the RBL-STEM approach with the learning materials developed by the researcher. While in the control class, we use the RBL-STEMapproach without the learning materials. Once we have implemented the learning process in both classes, the next step is to give a post-test to them to determine the students' creative thinking skills in the form of THBM.

A. The Validity and Reliability Test

Before using the instrument of learning outcomes test for creative thinking skills, we need to do a validity and reliability test. The validity test was carried out to ensure the suitability of the THBM question instrument with the student's creative thinking skills assessment. The test question instrument is said to be valid if the score value of Sig. (2-tailed) of all items, items are less than 0.05 (≤0.05) see in Table III.

Based on the results of the validity test, the calculated value of Sig. (2-tailed) of all THBM items starting from number 1 to question number 10 shows the calculated values of Sig. (2-tailed) 0.05. Thus, it can be concluded that the THBM question instrument for all questions is valid.

Apart from the validity test on THBM, we also did a reliability test. The reliability test is carried out to ensure the stability of ensuring the stability of the instrument so that if the instrument is used elsewhere, the instrument will still show the correct assessment of the respondents being assessed. The reliability test of the THBM question instrument in this study was also carried out with the help of the computer program. The results of the reliability test of THBM questions can be presented in Table IV below.

Based on Table IV, the reliability value of THBM questions shows a value of 0.794. THBM questions are said to be reliable if the result of the Alpha Croncbrach score is greater than 0.60. It can be concluded that the THBM questions are reliable.

TABLE IV: Reliability Test Results about THBM

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.794	0.754	10

B. The Homogeneity, Normality, Independent T-Test

This study began with a pre-test on 25 students in the control class and 30 students in the experimental class to establish their degree of creative thinking skills before analyzing the deployment of RBL-STEM learning materials. According to the results of the pretest in the control class, 1 (4%) student are in the very high category, 3 (12%) students are in the high category, 5 (20%) students are in the medium category, 9 (40%) students are in the moderate category, and 7 (28%) students are in the low category. The results of the pre-test of students in the control class see in Fig. 5.

TABLE III: THE RESULTS OF THE VALIDITY AND RELIABILITY TEST

Tes hasil uji validitas soal THBM												
		Soal_1	Soal_2	Soal_3	Soal_4	Soal_5	Soal_6	Soal_7	Soal_8	Soal_9	Soal_10	Soal_Total
Soal_1	Pearson Correlation	1	-0.394	0.049	0.145	-0.025	0.261	0.266	-0.025	0.290	-0.200	0.358
	Sig. (2-tailed)		0.051	0.817	0.490	0.906	0.208	0.200	0.906	0.160	0.337	0.049
	N	25	25	25	25	25	25	25	25	25	25	25
Soal _2	Pearson Correlation	-0.394	1	-0.166	-0.258	0.390	0.285	0.055	0.292	-.0101	0.289	0.342
	Sig. (2-tailed)	0.051		0.426	0.214	0.054	0.167	0.793	0.157	0.633	0.161	0.044
	N	25	25	25	25	25	25	25	25	25	25	25
Soal _3	Pearson Correlation	0.049	-0.166	1	-0.113	-0.251	-0.195	-0.029	0.078	0.219	0.166	0.404*
	Sig. (2-tailed)	0.817	0.426		0.591	0.226	0.351	0.892	0.710	0.292	0.427	0.045
	N	25	25	25	25	25	25	25	25	25	25	25
Soal_4	Pearson Correlation	,145	-,258	-,113	1	-,236	-,013	-,293	-,145	,000	,179	,050
	Sig. (2-tailed)	0.490	0.214	0.591		0.255	0.952	0.155	0.489	1.000	0.393	0.013
	N	25	25	25	25	25	25	25	25	25	25	25
Soal _5	Pearson Correlation	-0.025	0.390	-0.251	-0.236	1	0.136	0.140	-0.002	0.077	0.324	0.377
	Sig. (2-tailed)	0.906	0.054	0.226	0.255		0.518	0.504	0.991	0.714	0.114	0.043
	N	25	25	25	25	25	25	25	25	25	25	25
Soal _6	Pearson Correlation	0.261	0.285	-0.195	-0.013	0.136	1	0.089	0.278	-0.123	-0.123	0.342
	Sig. (2-tailed)	0.208	0.167	0.351	0.952	0.518		0.673	0.179	0.558	0.557	0.035
	N	25	25	25	25	25	25	25	25	25	25	25
Soal_7	Pearson Correlation	0.266	0.055	-0.029	-0.293	0.140	0.089	1	0.309	-0.178	-0.190	0.236
	Sig. (2-tailed)	0.200	0.793	0.892	0.155	0.504	0.673		0.133	0.396	0.364	0.025
	N	25	25	25	25	25	25	25	25	25	25	25
Soal _8	Pearson Correlation	-0.025	0.292	0.078	-0.145	-0.002	0.278	0.309	1	0	0.228	0.483*
	Sig. (2-tailed)	0.906	0.157	0.710	0.489	0.991	0.179	0.133		1.000	0.272	0.014
	N	25	25	25	25	25	25	25	25	25	25	25
Soal _9	Pearson Correlation	0.290	-0.101	0.219	0	0.077	-0.123	-0.178	0	1	0	0.416*
	Sig. (2-tailed)	0.160	0.633	0.292	1.000	0.714	0.558	0.396	1.000		1.000	0.039
	N	25	25	25	25	25	25	25	25	25	25	25
Soal _10	Pearson Correlation	-0.200	0.289	0.166	0.179	0.324	-0.123	-0.190	0.228	0	1	0.498*
	Sig. (2-tailed)	0.337	0.161	0.427	0.393	0.114	0.557	0.364	0.272	1.000		0.011
	N	25	25	25	25	25	25	25	25	25	25	25
Soal_Total	Pearson Correlation	0.358	0.342	0.404*	0.050	0.377	0.342	0.236	0.483*	0.416*	0.498*	1
	Sig. (2-tailed)	0.079	0.094	0.045	0.813	0.063	0.095	0.256	0.014	0.039	0.011	0.021
	N	25	25	25	25	25	25	25	25	25	25	25

*. Correlation is significant at the 0.05 level (2-tailed).

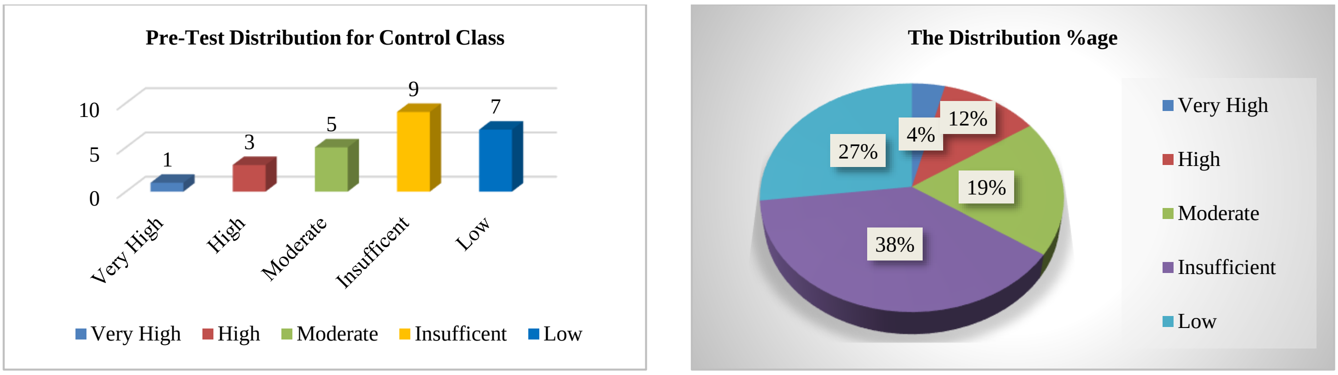
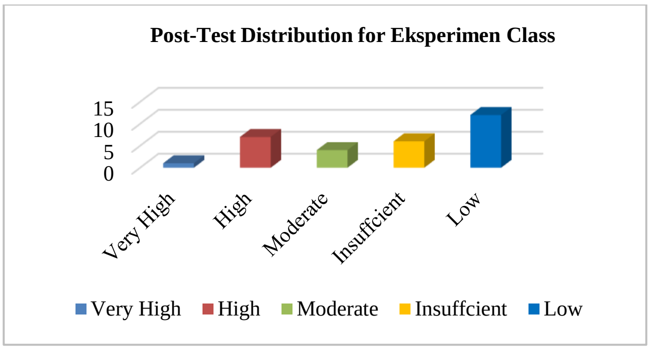


Fig. 5. The distribution of student's creative thinking skills based on their pre-test.

In addition, 30 students in the experimental class were given a pre-test to identify their creative thinking abilities. According to the results of the pretest in the control class, 1 (3 %) of students have very high creative thinking skills, 7 (23 %) have high creative thinking skills, 4 (13 %) have medium creative thinking skills, 6 (20 %) have moderate creative thinking skills, and 12 (41 %) have low creative thinking skills. The results of the pre-test of students in the experimental class see in Fig. 6.



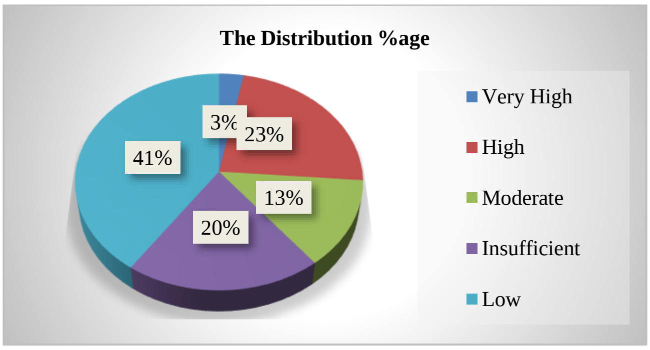
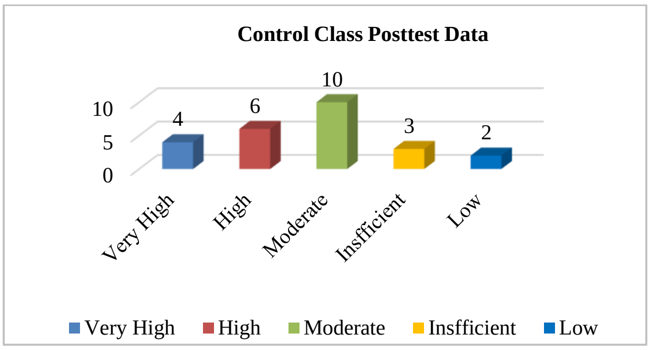


Fig. 6. The distribution of student's creative thinking skills based on their post-test.

The research was subsequently continued by having both classes participate in the learning process. The control class was taught using RBL-STEM and no learning materials developed as part of this study, while the experiment class was taught using RBL-STEM and learning materials developed as part of this study. The learning outcomes of the pupils are then assessed using a post-test at the end of the class. According to the results, 4 (16%) students in the control class have very high creative thinking skills, 6 (24%) students have high creative thinking skills, 10 (40%) students have moderate creative thinking skills, 3 (12%) students have insufficient creative thinking skills, and 2 (8%) students have low creative thinking skills. The post-test results of students in the control class are depicted see in Fig. 7 as follows.



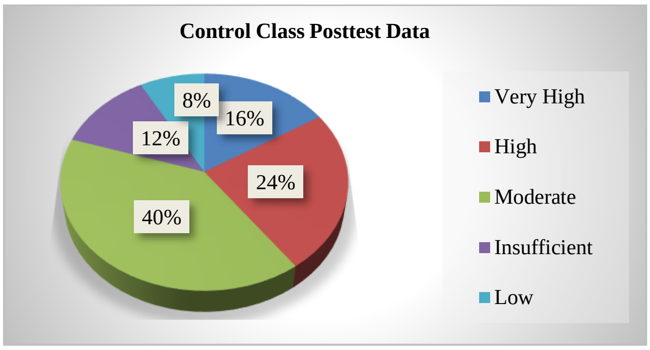
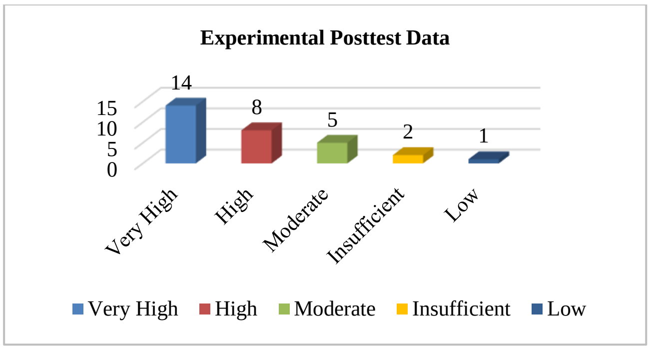


Fig. 7. The distribution of student's creative thinking skills based on their post-test.

Meanwhile, the post-test results of the 30 students in the experimental class revealed that their creative thinking skills were divided into 14 (47%) students in the very high category, 8 (27%) students in the high category, 5 (17%) students in the moderate category, 2 (6%) students in the insufficient category, and 1 (3%) student in the low category. The results of the post-test of students in the experimental class see in Fig. 8 as follows.



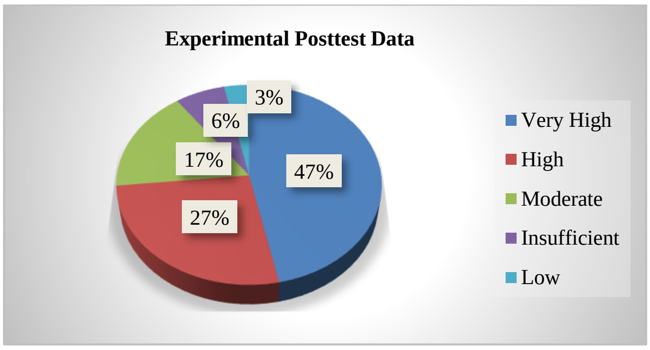


Fig. 8. The distribution of student's creative thinking skills based on their post-test.

We'll also look at how effective RBL-STEM is at improving students' creative thinking skills when it comes to solving the problem of using chitosan as an antibacterial for processed meat. We must first check the data for homogeneity and normality before proceeding with the analysis. The pre-test data is used in the homogeneity test, whereas the post-test data is used in the normalcy test. According to Table V, the homogeneity test results, the value (Sig.) of the homogeneity variance score is 0.335>=0.05, indicating that the two data are homogeneous variance. According to see in Table VIII, the results of each group's normality test yielded a value (Sig.) of 0.083 for the control class and 0.091 for the experiment class. Because the significant value of the two classes is more than 0.05, the two data sets from the research samples are normally distributed see in Table.VI.

TABLE V: THE HOMOGENEITY TEST OF THE PRE-TEST DATA OF TWO CLASSES

Test of Homogenity of Variances					
		Levene Statistic	df1	df2	Sig.
THBM	Based on Mean	0.947	1	53	0.335
	Based on Median	0.933	1	53	0.339
	Based on Median and with adjusted df	0.933	1	52.985	0.339
	Based on Trimmed Mean	0.936	1	53	0.338

TABLE VI: THE NORMALITY TEST OF THE POST-TEST DATA OF TWO CLASSES

Tests of Normality							
	Class	Kolmogorov-Smirnova			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
THBM Posttest	1.00	0.164	25	0.083	0.931	25	0.189
	2.00	0.213	30	0.091	0.832	30	.p

a. Lilliefors Significance Correction

TABLE VII: THE RESULT OF INDEPENDENT SAMPLE T-TEST ON POST-TEST DATA

Independent Samples Test										
		Levene's Test For Equality of Variences		T-test for Equality of Means						
		F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Hasil THBM	Equal variences assumed	0.408	0.526	4.884	53	0	17.233	3.529	10.156	24.311
	Equal variences not assumed			4.788	45.834	0	17.233	3.529	9.987	24.479

TABLE VIII: THE COMPARISON OF THE MEAN OF POST-TEST DATA BETWEEN TWO CLASSES

Group Statistics					
	Class	N	Mean	Std. Deviation	Std. Error Mean
Post-Test	Experiment Class	30	84.63	11.669	2.131
	Control Class	25	67.40	14.506	2.901

TABLE IX: THE ANALYSIS OF THE PRACTICALITY OF THE IMPLEMENTATION OF RBL-STEM

No		Assessment Aspects	Meeting Cycle 1	2	3	Average (%)
		RBL-STEM Syntax				
I	1.	The level of the implementation rate for all learning stages	4	4	4	100%
	2	The implementation of the sequence of learning activities reflecting the research-based learning on developing the students creative thinking skills	3.5	4	3.75	93.75%
		Emotional Students Response				
II	1.	The level of the learninng atmosphere (forming groups, discussing, asking, debating, submitting opinions, respecting each other at work)	3	3.5	3.75	93.75%
	2.	The level of interaction in the learning process (student-student, and student-teacher)	3.5	4	3.75	93.75%
	3.	The orientation of the concepts develops the students creative thinking skills under the implementation of research-based learning with a STEM approach	4	4	4	100%
		Response and Pedagogical Management				
III	1.	The level of lecturer's accommodation in providing opportunities for students to ask questions, submit opinions, and provide feedback	4	4	4	100%
	2.	The level of implementation of the behavior of lecturers providing assistance, guidance, guiding students in learning	3.5	4	3.75	93.75%
	3.	The level of implementation of lecturer behavior motivates the students to involve actively in the learning process	3	3.5	3.75	93.75%
	4.	The level of implementation of lecturer behavior motivates the students to actively ask some questions	4	4	4	100%
	5.	The level of implementation of lecturers facilitates the student to access some relevants links	3.5	4	3.75	93.75%
		Average score per meeting	3.6	3.9		
		Percentage of average score per meeting	90%	97.5%		
		Average overall score				3.85
		Percentage of the overall average score				96.25%

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Now we've reached the final level of testing, the independent sample t-test, to see how effective RBL-STEM was in enhancing the students' creative thinking skills in solving the problem of using chitosan as an antibacterial for processed meat. Refer to see in Table VII for the results, which demonstrate that the Sig. (2-tailed) is 0.000<0.05 based on the independent sample t-test result. It means the null hypothesis Ho isn't true. As a result, in terms of the average post-test scores, there is a substantial difference between the control and experimental groups. It is concluded that combining the RBL learning model with the STEM method has a substantial impact on students' creative thinking skills when it comes to solving the problem of using chitosan as an antibacterial for processed beef. The average score on the experiment class's creative thinking skill exam seen in Table VIII is 84.63, while the control class's score is 67.40. It appears in a slightly different way see in Table VIII

The next analysis is the observation of the practicality of the implementation of RBL-STEM. Based on Table IX, shows that RBL-STEM Syntax implementation is gained 96.87% which is a very good category, the emotional student's response is gained 95.83% which is a very good category, and the Response and Pedagogical Management is gained 96.25% which is a very good category. Overall practicality is 96.31%, see in Table IX with a very good category see in Table IX.

Furthermore, we observed students' learning activities in the experimental class while using the RBL model with the STEM approach. Based on see in Table X, the data shows that the average score of the student's activities in the introduction stage of learning activities is 100% which shows a very active category, in the main stages of the learning activities is 94.75% which shows a very active category, and at the last stage of learning activities is 100% which shows a very active category. Thus, from the three stages of the learning activities, the average value is 98.25%. It can be concluded that the implementation of the RBL model with the STEM approach can improve the student learning activities seen in Table X.

C. *Portrait Phase*

The phase portrait is a description of the flow of the student's thinking process in solving a problem. In this study, the student phase portrait was based on indicators of creative thinking skills in solving the problem of chitosan as a natural preservative for processed meat. Interviews were conducted on students and asked them to take or choose an indicator card for creative thinking skills. The flow of student thinking can be seen based on the results of student work in completing the post-test which is then interviewed on the results of the student's work. The results of the first work are the work of students in the very creative category; the second is students with creative categories; and the third is students with quite creative category. Students can solve all problems in the use of chitosan as a natural preservative in processed meat which consists of explaining shrimp shell waste caused by the shrimp production industry, describing whether the shrimp shell waste has a negative impact on health and the environment, determining the use of shrimp shells, examining the skin whether shrimp can be processed into chitosan, checking data via the internet regarding the content of chitosan, concluding data regarding the function of chitosan, designing the stages of chitosan manufacturing, designing tools and materials for making chitosan, giving arguments on how to test the effectiveness of chitosan, and designing methods for testing the effectiveness of chitosan as a natural preservative. processed meat, while the side with the direction represents the student's see in Table XI flow of thinking sequentially starting from the first selected indicator card followed by the next card see in Table XI

TABLE X: THE RECAPITULATION OF OBSERVATIONS SCORES ON STUDENT LEARNING ACTIVITIES

Stages	Indicators	Meeting Cycle 1	Meeting Cycle 2	Average	Average (%)
Introduction stage	Introduction stages of the learning activities	4	4	4	100%
Main stage	Main stages of the learning activities	3.75	3.83	3.79	94.75%
Last stage	Last stage of the learning activities	4	4	4	100%
Average score per meeting		3.92	3.94		
Average score percentage per meeting		98%	98.5%		
Average overall score				3.93	
The average percentage of the overall score				98.25%	

TABLE XI: INDICATORS OF CREATIVE THINKING SKILLS

Indicator	Sub Indicator
Fluency (Fluent thinking skills)	Students are able to explain shrimp shell waste caused by the shrimp production industry which will have a negative impact on the environment (F1)
	Students are able to describe whether shrimp shell waste caused by the shrimp production industry will have a negative impact on health (F2)
Flexibility (Flexible thinking skills)	Students are able to determine the possibility of using shrimp shell waste as a natural preservative for processed meat (B1)
	Students are able to examine whether the shrimp shell waste can be processed into something more useful, for example chitosan (B2)
Originality (Original thinking skills)	Students are able to search for data through the internet what students know about the definition, raw materials, characteristics, and content of chitosan as a natural preservative for processed meat (O1)
	Students are able to conclude via the internet about the function of chitosan as a natural preservative for processed meat (O2)
Elaboration (Detailing skills)	Students are able to design the process/steps in making chitosan from shrimp shells (E1)
	Students are able to prepare tools or materials used in making chitosan from shrimp shells (E2)
	Students are able to provide arguments on how to test the effectiveness of chitosan as a natural preservative against processed meat through organoleptic testing (E3)
	Students are able to design a method of testing the effectiveness of chitosan as a natural preservative against processed meat through organoleptic and bacterial tests (E4)

Phase portraits of students' creative thinking skills are schematic visualizations obtained from the process of acquiring creative thinking skills through interview techniques and phase portrait control cards. The phase portrait control card is a card that contains sub-indicators used by researchers to conduct in-depth interviews with research subjects. There are 10 sub-indicators of creative thinking ability, so the number of cards is 10, see Fig. 9.

Then the card is given to students who are selected from research subjects with creative thinking skills, namely very creative, creative, and quite creative. The interview transcript was recorded, then adjusted to the control card, the code was recorded, and the sequence was recorded to then be poured in the form of a phase portrait. In this study, three portrait phases are shown, namely the portrait of the creative thinking ability of students from the experimental class with categories of very creative (S25KE) see in Fig.10, Fig. 11, and Fig. 12. Creative (S15KE) see in Fig. 13, Fig. 14, see in Fig. 15 and quite creative (S9KE) see in Fig. 16, Fig. 17 and see in Fig. 18. By using MATLAB programming, this phase portrait can be analyzed in several ways: first, the adjacency matrix of creative thinking abilities with degrees one and three, then the degree of each node is analyzed, the number of paths/paths are one and three distances apart, the number of sides and the number of cycles it has.

Note: The writing on the cards is derived from creative thinking sub-indicators and then on the back of the cards a code is given according to the codification of creative thinking sub-indicators such as F1, F2, B1, B2, O1, …. etc. At the time of the interview, the research subjects did not understand the codes of the cards. While presenting the problem taken from one of the post-test questions, the researcher conducted an interview process to ask the order in which the problem was solved based on the card. Each answer is associated in the form of a phase portrait image.

Fig. 9. Interview control card to get a portrait of the research subject's creative thinking ability phase.

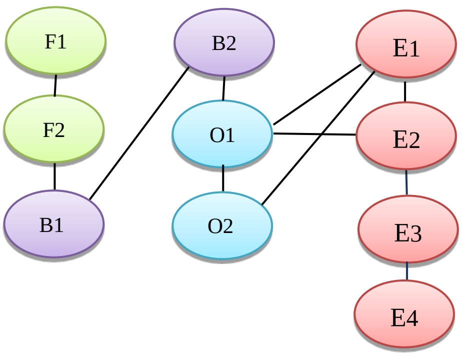


Fig. 10. Portrait of the creative thinking ability phase of the S25KE research subject with 10 knots and 13 sides with a very creative category.

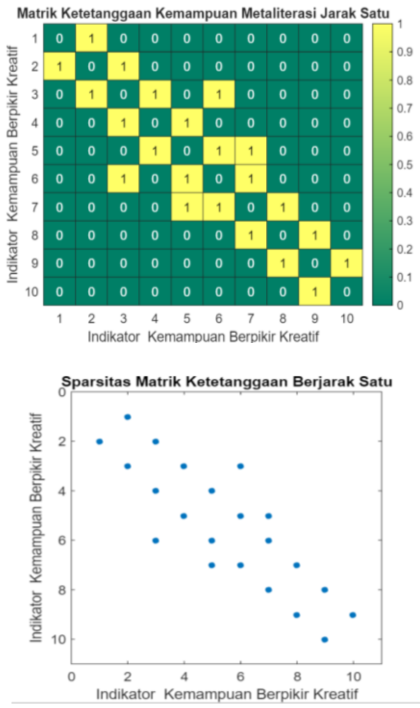


Fig. 11. Neighbourhood matrix of creative thinking ability is one subject of S25KE research.

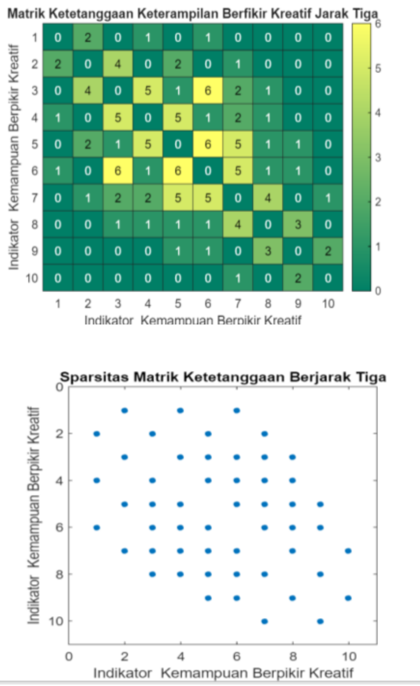


Fig. 12. Neighbourhood matrix of creative thinking ability is three research subjects S25KE.

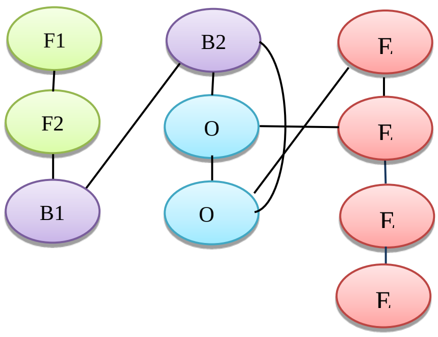


Fig.13. Portrait of the creative thinking ability phase of the S15KE research subject with 10 knots and 11 sides with creative categories.

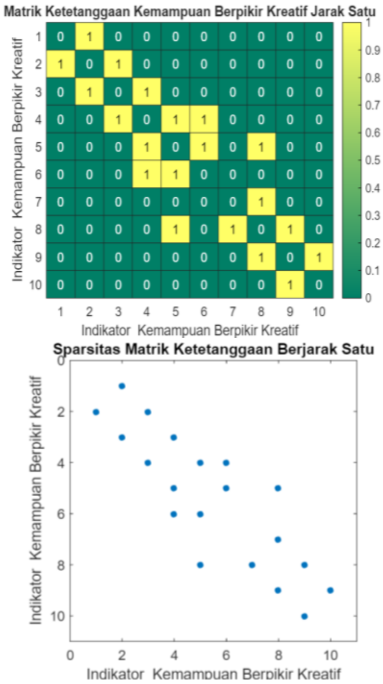


Fig. 14. Neighbourhood matrix of creative thinking ability is one research subject S15KE.

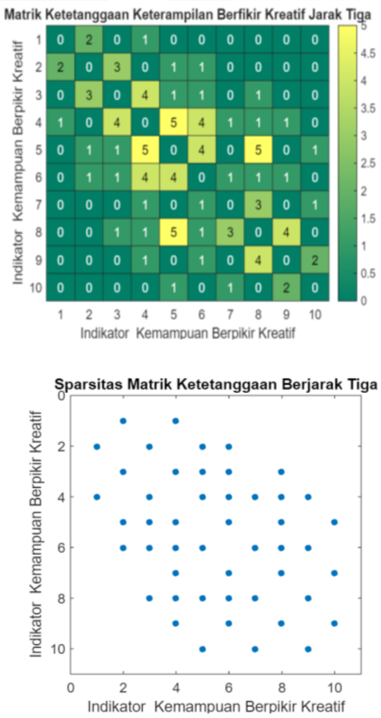


Fig. 15. Neighbourhood matrix of creative thinking ability is three research subjects S15KE.

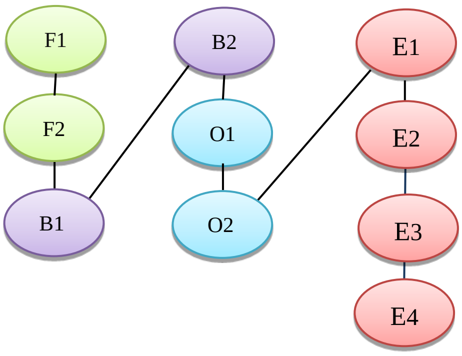


Fig.16. Portrait of the creative thinking ability phase of the S9KE research subject with 10 vertices and 8 sides with sufficient category.

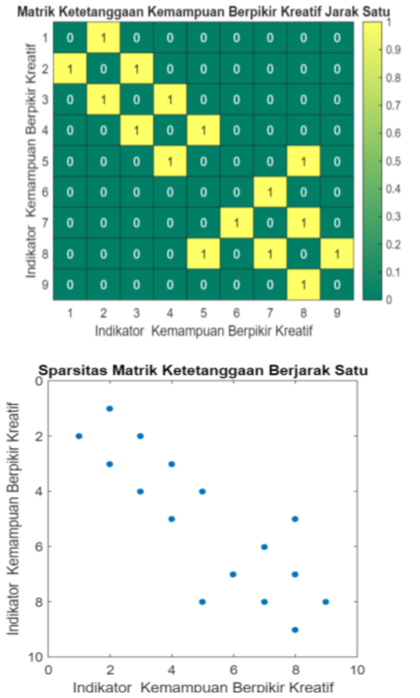


Fig.17. Neighbourhood matrix of creative thinking ability is one subject of S9KE's research.

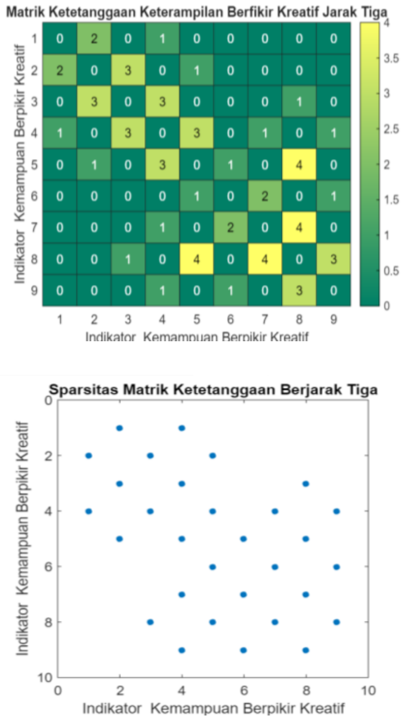


Fig 18. Neighbourhood matrix of creative thinking ability is three research subjects S9KE.

Based on the three portraits of students' creative thinking skills, for the very creative category, S25KE research subjects show the fact that their creative thinking skills are comprehensive from F1 to E4 and in general the maximum value of the neighbouring matrix is more than one, the maximum value of the thinking step is obtained. The creativity of the S25KE research subjects is greater than the S15KE research subjects. Furthermore, in the neighbouring matrix three distances, see in Fig. 12, 15 and 18 showing that the maximum number of grooves on the creative thinking ability of the S25KE research subjects is higher than the others. This shows that the creative thinking flow of the S25KE research subject students is more flexible than others, because there are many alternative paths in solving problems. In contrast to the portrait of the S9KE phase which shows discontinuities and jumps from O1 directly to E3 which illustrates the flow of creative thinking that is not schematic and from the results of the interview, the results of the work are also not optimal. The maximum degree of each node of the creative thinking sub-indicator of the S25KE research subject phase portrait is 4, namely at O1, and the number of sides is 13, while in S15KE and S9KE it is 3, namely at node O1 and the number of sides is 13 and 11, respectively. , this indicates that a node with a high degree is a sub-indicator of creative thinking ability that is more often passed in solving a given problem.

Finally, the most important in this phase portrait analysis is the calculation of node integrity as formulated by Hiler and Hanson (1984). It is stated that the value of integrity can be determined from the calculation of RRA (Real Relative Asymmetry). The minimal RRA value indicates a high integrity value, meaning that the connectivity of the node with low RRA in the phase portrait has the closest unity compared to other nodes. Another meaning is that this node is the node that is most frequently passed and reached in the creative thinking process of the research subject.

The RRA value was calculated from the analysis of Total Depth (TD), Mean Depth (MD) and Relative Asymmetry (RA). Total Depth (TD) is the total trajectory length of the observed sub-indicators see in Table XII, Table XIII and Table XIV, Mean Depth:

$$MD = \frac{TD}{n-1}, \text{ and } RA = \frac{2(MD-1)}{n-2}, \text{ then } RRA = \frac{RA}{GL}, \text{ where } GL = 2\,\frac{n\sqrt{n}-2n+1}{(n-2)(n-1)}. \quad (1)$$

From this formula, the distribution of values is obtained in the following see in Table XII:

TABLE XII: VALUE OF REAL RELATIVE ASYMMETRY (RRA) DISTRIBUTION OF S25KE STUDENTS

Simpul	F1	F2	B1	B2	Q1	Q2	E1	E2	E3	E4				TD	MD	RA	GL	RRA
F1	0	1	2	3	4	4	3	4	5	6	7			39	4.3333	0.8333	0.3506	2.3767
F2	1	0	1	2	3	3	2	3	4	5	6			30	3.3333	0.5833		1.6637
B1	2	1	0	1	2	2	1	2	3	4	5			23	2.5556	0.3889		1.1091
B2	3	2	1	0	1	2	2	2	3	4	5			25	2.7778	0.4444		1.2675
Q1	4	4	4	4	2	2	1	0	1	1	2	3	4	32	3.5556	0.6389		1.8221
Q2	3	2	1	2	2	1	0	1	2	3	4			21	2.3333	0.3333		0.9507
E1	4	3	2	2	1	1	0	1	2	1				17	2.1111	0.2778		0.6338
E2	5	4	3	3	2	2	1	0	1	2				23	2.5556	0.3889		1.1091
E3	6	5	4	4	3	3	2	1	0	1				29	3.2222	0.5556		1.5844
E4	7	6	5	5	4	3	1	0						31	3.4444	0.6111		1.7429

TABLE XIII: REAL RELATIVE ASYMMETRY (RRA) DISTRIBUTION VALUE FOR S15KE STUDENTS

Simpul	F1	F2	B1	B2	Q1	Q2	E1	E2	E3	E4		TD	MD	RA	GL	RRA
F1	0	1	2	3	4	4	6	5	6	7		38	4.2222	0.8056	0.3506	2.2974
F2	1	0	1	2	3	3	5	4	5	6		30	3.3333	0.5833		1.6637
B1	2	1	0	1	2	2	4	3	4	5		24	2.6667	0.4167		1.1883
B2	3	2	1	0	1	1	3	2	3	4		20	2.2222	0.3056		0.8714
Q1	4	3	2	1	0	1	2	1	2	3		19	2.1111	0.2778		0.7922
Q2	4	3	2	1	1	0	3	2	3	4	7	32	3.5556	0.6389		1.8221
E1	6	5	4	3	2	3	0	1	2	3		29	3.2222	0.5556		1.5844
E2	5	4	3	2	1	2	1	0	1	2		21	2.3333	0.3333		0.9507
E3	6	5	4	3	2	3	2	1	0	1		27	3.0000	0.5000		1.4260
E4	7	6	5	4	3	4	3	2	1	0		35	3.8889	0.7222		2.0598

TABLE XIV: VALUE OF REAL RELATIVE ASYMMETRY (RRA) DISTRIBUTION OF S9KE STUDENTS

Simpul	J1	J2	J3	J4	J5	J6	J7	J8	J9	TD	MD	RA	GL	RRA
F1	0	1	2	3	4	7	6	5	6	34	3.7778	0.6944	0.3506	1.9805
F2	1	0	1	2	3	6	5	4	5	27	3.0000	0.5000		1.4260
B1	2	1	0	1	2	5	4	3	4	22	2.4444	0.3611		1.0299
B2	3	2	1	0	1	4	3	2	3	21	2.3333	0.3333		0.9507
Q1	4	3	2	1	0	3	2	1	2	18	2.0000	0.2500		0.7130
Q2	7	6	5	4	3	0	1	2	3	31	3.4444	0.6111		1.7429
E1	6	5	4	3	2	1	0	1	2	24	2.6667	0.4167		1.1883
E2	5	4	3	2	1	2	1	0	1	19	2.1111	0.2778		0.7922
E3	6	5	4	3	2	3	2	1	0	26	2.8889	0.4722		1.3468
E4														

Based on Tables XII, XIII, and XIV, namely the RRA distribution table from each node Q2 for phase portraits of research subjects S25KE, S15KE and S9KE, it is found that the lowest value of RRA nodes E2, Q1 and E4 in each phase portrait of research subjects S25KE, S15KE and S9KE. Thus, the three points in the three phase portraits have integrity values compared to other nodes. Thus, the F2, F2, Q2 sub-indicators have a better relative asymmetry value than the others. Then, if we compare the conditions of the third phase portrait, then the comparison can be presented in the following Table XV.

TABLE XV. PHASE COMPARISON OF STUDENT CREATIVE THINKING SKILLS

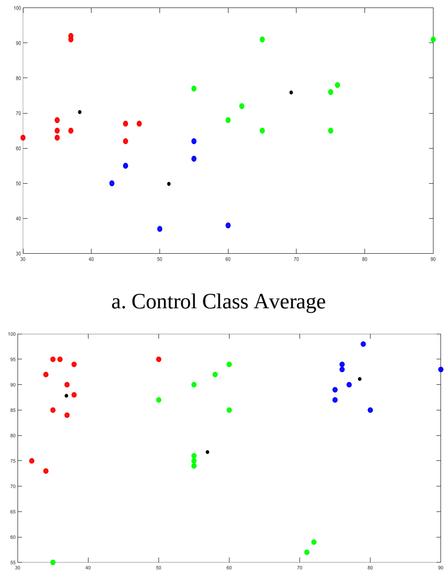
Student	Size	Maks $\mathbf{d}(\mathbf{x})$	Maks A^3	Min RA
S25KE with very creative thinking	12	4	6	0.6338
S15KE with creative thinking	11	3	5	0.7922
S9KE with quite creative thinking	8	2	4	0.9507

IV. DISCUSSION

This study looked at how the research-based learning (RBL) model was used in conjunction with the STEM approach, and how it affected students' creative thinking skills when it came to solving the challenge of employing chitosan from shrimp shells as a natural preservative for processed meat. According to the results of the pretest in the control class, 1 (4%) student fall into the very high category, 3 (12%) students fall into the high category, 5 (20%) students fall into the medium category, 9 (40%) students fall into the sufficient category, and 7 (28%) students fall into the low category for creative thinking skills. Furthermore, based on the results of the pretest in the experimental class, it is known that 1 (3%) of students fall into the very high category, 7 (23%) fall into the high category, 4 (13%) fall into the medium category, 6 (20%) fall into the moderate category, and 12 (41%) fall into the low category in terms of creative thinking skills. This demonstrates that the control and experimental classes' early abilities in creative thinking skills are equal.

Furthermore, the students' creative thinking skills were determined based on the control class's post-test results, with 4 (16%) students falling into the very high category, 6 (24%) students falling into the high category, 10 (40%) students falling into the medium category, 3 (12%) students falling into the sufficient category, and 2 (8%) students falling into the low category. The student's creative thinking skills were assessed in the experimental class, with 14 (47%) students falling into the very high category, 8 (27%) students falling into the high category, 5 (17%) students falling into the medium category, 2 (7%) students falling into the sufficient category, and 1 (3%) student falling into the low category. This demonstrates that the experimental class's creative thinking skills are significantly higher than the control classes. It's because of the RBL-STEM learning materials' application.

An independent sample t-test was used to demonstrate the significance of the effect of combining the RBL model with the STEM approach on students' creative thinking skills. The null hypothesis (Ho) that there is no significant effect of implementing the RBL learning model with the STEM approach on students' creative thinking skills in solving the problem of using chitosan as a natural preservative for processed meat was rejected, while the working hypothesis (Ha) that there is a significant effect of implementing the RBL learning model with the STEM approach on students' creative thinking skills in solving the problem of using chitosan as a natural preservative for processed meat was rejected. The data clustering of the mean score of the post-test result in Fig. 19 demonstrates that there is a substantial difference between the post-test average on the control class and the experimental class. The clustering reveals that the majority of the experiment class's mean scores are distributed on the upper side of the coordinate system, while the majority of the control class's mean scores are distributed on the lower side see in Fig.19.



a. Control Class Average

b. Experimental Class Average

Fig. 19. The data clustering of mean score of post-test results between two classes.

This is in line with the results of research conducted (Wahyuni *et al*., 2020), (Rohim *et al*., 2019), (Ridlo *et al*., 2020), (Dsafik, 2015). The lecturer is a motivator in directing students to tackle the challenges they experience since the steps of the RBL learning model stress student-centered learning. Students are encouraged to recognize difficulties and build problem-solving skills based on their experiences in the lab. Furthermore, based on the practicality analysis of the implementation of RBL-STEM, we have found the overall practicality is 96.31% with a very good category. Moreover, the recapitulation of observation scores on student learning activities achieves 98.25% in the very active category. As a result, it can be stated that employing the RBL learning model in conjunction with the STEM approach has a substantial impact on students' creative thinking skills when it comes to solving the challenge of using chitosan as a natural preservative for processed meat.

V. CONCLUSION

We conducted this study and discovered that combining a research based (RBL) model with a STEM (science, technology, engineering, and mathematics) approach has a considerable impact on students' creative thinking abilities in the experimental class. In the experimental class, the learning outcome on their creative thinking skills was higher than in the control class. During the implementation of the RBL learning model with the STEM approach, student learning activities exhibit a very active category. It can be concluded that the implementation of the RBL learning model with the STEM approach has a significant influence on students' creative thinking skills.

ACKNOWLEDGMENT

We gratefully acknowledge the support of the DRPM-Kemendikbud RI for providing the Doctoral Dissertation Research Grant (PDD) for the year 2022.

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Rina S. D. Gita was born in Jember on October 16, 1985. She completed elementary school in 1997 at SD Negeri Sumberjo 4 Ambulu, the junior high school in 2000 at SLTP Negeri 2 Ambulu, the senior high school in 2003 at SMU Negeri 1 Jenggawah. She completed the undergraduate degree in 2007 at FP MIPA Biology IKIP PGRI Jember, and completed her master's degree in 2005 S2 at FMIPA Biology University of Jember. Now, she has been studying her doctoral program at the Science Education Study Program, FKIP University of Jember since 2020. She has been an active lecturer for Biology Study Program, Faculty of Science and Technology, Universitas PGRI Argopuro Jember (UNIPAR) since 2015 until now.

Joko Waluyo was born on October 28, 1957, in Klaten, and received his bachelor's degree at UNS Surakarta in 1984, Master's degree at ITB Bandung in 1993, Doctorate degree at UNAIR Surabaya in 2004 and he received his professor in 2009. Currently, he is a lecturer at Biology Education at FKIP University of Jember and became Deputy of Dean for staff and finance affair in the Faculty of Teacher Training and Education at the University of Jember for the 2017-2021 periods. There have been many research grants that he has received starting from basic research grant, competitive research grant, national strategy research grant, national strategy excellence grant, developmental research grant from the Ministry of Research, Technology and Higher Education. He has published many papers in reputable international journals, and he also wrote some books on Basic Biology, General Biology, and Microbiology.

Dafik was born in Situbondo on August 2, 1968. In 1987–1992, he studied at the undergraduate level at the Department of Mathematics Education, University of Jember. In 1996–1998, he studied at the master's level in Mathematics: Numerical Computation at the University of Manchester Institute of Science and Technology Manchester, UK. In 2004–2007, he studied at the doctoral level in Mathematics: Combinatorics and Graph Theory at the University of Ballarat, Victoria, Australia. He obtained the Professor in the fields of Combinatorics, Graph Theory and Network Topology. He was dean of FKIP-UNEJ 2016-2020, and now he has a chairman of PUI-PT Combinatorics and Graphs, CGANT-University of Jember. He is a very active and productive researcher, since he has more than 300 hundred papers published in international reputable journals.

Indrawati was born in Demak on June 10, 1959. In 1978-1981 completed her undergraduate program at the Department of Physics Education, FKIE IKIP Semarang and continued the S1 Physics Education Program in the same Department until 1984. In 1993-Year 1997 studied Master of Science Program at UPI and in 1999-2005 took the Doctoral Program in Science Education at the same university. Her professor was obtained in 2014 in the field of science education. She is currently coordinator of the research group "21st Century Science Teaching Model" in the Master of Science Education Study Program, FKIP UNEJ.