The Effect of the Modellus-Based PBL Model on the Critical and Creative Thinking of Class IX High School Students on Wave Material

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Abstract. This study aims to describe students' critical and creative thinking skills using the problem-based learning (PBL) learning model based on modellus software on wave physics material. After conducting quasi-experimental research with two group pretest-posttest designs, the results of the modellus-based problem-based learning model significantly affect students' critical and creative thinking skills. The results of the multivariate analysis of variance pretest critical and creative thinking obtained Fcount = 0.207 and significant = 0.814. As for the posttest Fcount = 32.42 significant = 0.000 at the level of 0.05. The statistical test for the N-Gain of students' critical thinking skills in the experimental class was 41% and the control class was 35%. In the experimental class, the N-Gain of creative thinking skills is 41% and the control class is 29%.

Keywords: Model problem-based learning (PBL), Modellus software, critical and creative thinking

1 Introduction

Education in school has goals that are in line with the goals of national education. The 2013 curriculum targets to increase the creativity of students as optimally as possible so that they are able to innovate to answer future challenges [1]. Students will be able to innovate if they have creative thinking [2-4]. Creative thinking can be demonstrated through the ability to build and create ideas, discover new things that have never existed, plan something new, and display it. Concept understanding is the basis for students to develop and connect concepts with one another so that they are able to solve problems in physics. The wave material in learning has material characteristics that can be delivered with existing concepts in everyday life so that it is easy for students to understand. According to the characteristics, actually wave material can be found and occurs in everyday life, so there are many problems related to waves that can be used as references or guidelines in learning. Understanding physics material requires thinking and reasoning in order to solve physics problems. The same opinion was expressed by Kuswana

(2012) who states that the development of thinking skills is the basis for building one's knowledge, attitudes, and motor skills. So also with Jones et al (2012) mentions that one's thinking skills are used to detect, analyze and evaluate possibilities that occur in the future which are very important to be developed in education. Education should make the ability to think as the main goal of education by providing facilities for developing thinking skills that are larger in portion. Critical thinking is needed in learning physics, including the topic of waves. Judging from the context of improving the quality of education, the problem-based learning (PBL) model is one of the learning models that can be used to improve the learning system [5]. We realize that so far the ability of students to be able to solve problems has not been noticed by every teacher in learning. The problem-based learning (PBL) model places problems as the keyword of the learning process. Use The problem-based learning (PBL) learning model aims to guide students to become individuals who have thoughts like adults so that they can students are able to develop their abilities and be able to think critically (Sugiharto, 2015). Critical thinking according to Soyomukti (2015) is a cognitive skill that allows a person to investigate a situation, problem, question, or phenomenon in order to make an assessment and decision [6]. Related to the problem that happened in learning physics in school, the researcher needs to apply an appropriate learning media and could resolve the difficulty of students in the study. Based on the problem above so need to be conducted something method for resolving the problem then that is as using an integrated PBL problem-based learning model with software-based media that can help students to more creative, critical, and easier to understand draft physics for solving physics problems in everyday life [7-8]. In Thing, this writer chooses to use the device soft modellus. Election use this software because this software is capable answer phenomena in physics in connection with mathematics. By using the features contained in the modeler's software media characteristics of the material waves can be visualized and simulated by mathematics well so that the mastery of the students' material is increasing. Besides could simulation modelus software also can be used to present results in the form of animation objects, tables and charts [9].

2 Methods

The research design used was a quasi-experimental design with a two-group pretest-post-test design. The data analysis technique used in this research is the descriptive quantitative data analysis technique. The quantitative descriptive analysis technique was obtained from a descriptive questionnaire which was then quantified in order to get the results in the form of numbers. The population in this study were all students of XI MIPA Semester 2 (two) Chandra Kumala High School for the Academic Year 2021/2022. The sample in this study consisted of two classes selected by cluster random sampling technique, namely each population class has the right to have the opportunity to become the research sample. Samples were taken from the population in as many as two classes. One class is used as an experimental class (a class that is taught by applying a problem-based learning (PBL) model. Modellus media-based and another class is used as a control class ((classes taught by applying the problem-based learning (PBL) model) without using modellus media).

Tabel 2.1 *Two Group Pretest t – Posttest t Design*

Group	Pretest	Treatment	Postes
Experiment class	T1	X	T2
Control class	T1	Y	T2

Information:

T_1 = Pretest given to the experimental and control classes before treatment
T_2 = Posttest given after treatment in the experimental class and control class
X = Teaching with problem based learning model- based on media modellus
Y = Teaching with a problem-based learning model based on without media modellus

3 Results

Results obtained in a study describing start from data acquisition pretest and posttest think a critical and creative student at Chandra Kumala High School Deli Serdang. Instrument tests are given to students there are two types of instrument that is instrument think critical and instrument think creative. Instrument think critical consists of five questions and instrument consists of five questions think creative who has validated. As for the results study, this description starts from data acquisition pretest and posttest think critical and creative students. Results Calculation of science process skills pretest data and ability solving problem physics student showed on Table following.

**Table 3.1** Test of normality Data Pretest Critical and Creative Thinking

|	Tests of Normality						
		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Pretest Results	Statistic	df	Sig.	Statistic	df	Sig.
Pretest Results	Critical Thinking Pre-Test Score.	.24	15	.01	.91	15	.13
	Critical Thinking Control Pre	.21	15	.06	.89	15	.08
	Creative Thinking Pre-Tets	.16	15	.20	.93	15	.31
	Creative Thinking Control Pre-Tets	.28	15	.02	.88	15	.06

3.1 Test Normality

Pretest Test pretest normality are helped with application *SPSS 25.0 for windows* with use level significant 0.05 and condition testing if score significant on column *Kolmogorov-Smirnov* bigger from 0.05 so data considered distribute normally. Results testing normality could be seen in Table 3.1.

Based on the results test pretest normality using test *Kolmogorov- Smirnov* value significance ability thinks critical namely 0.014 and 0.069. Whereas the ability thinks creatively namely 0.200 and 0.002. This data show that score significance ability thinks critical and creative student bigger from level 0.05, which means class pretest score control distribute normally.

Based on the results of test normality that's can conclude that the second sample distribute normally. Calculation test normality pretest also could prove through histogram which showed on the Figure.
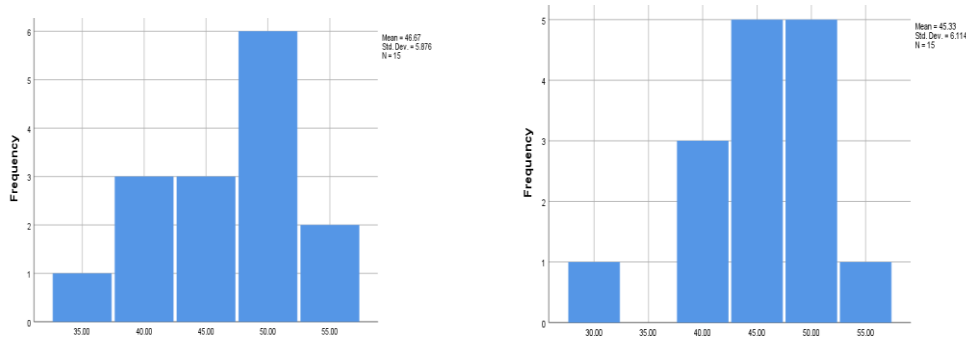
Fig. 3.1 Test Normality Think Critical
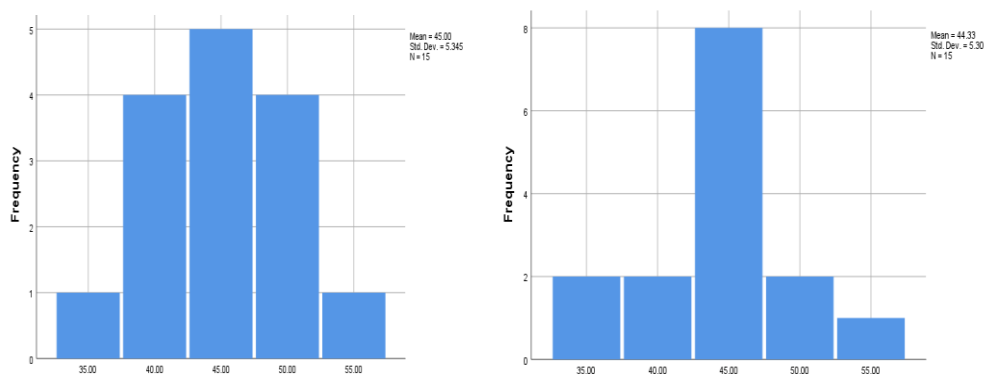
Fig. 3.2 Test Normality Creative

3.2 Test Homogeneity

Homogeneity test is used to determine the sample is homogeneous or not. Testing the homogeneity of the two variances between the experimental class and the class control with *Levene's test* assisted test SPSS 25.0 *for windows application*. Condition homogeneity test if

the significance value is greater than 0.05 then the data considered homogeneous. Results testing homogeneity showed on table following

Table 3.2 Test Homogeneity Pretest

Pretest Results		Kolmogorov-Smirnov [a]			Shapiro- Wilk		
		Statistics	df	Sig.	Statistics	df	Sig.
PreTest Score	Thinking PreTest Critical	0.21	15	0.05	0.90	15	0.11
	PreTest Control Think Critical	0.23	15	0.02	0.90	15	0.11
	Pre Drops thinking Creative	0.16	15	.20 *	0.93	15	0.33
	Pre Drops Control thinking Creative	0.23	15	0.02	0.88	15	0.05

Based on results test homogeneity pretest use *Levene's test* obtained score significance critical thinking skills is 0.711 and score significance ability creative thinking is 0.786. Score significance which obtained is greater than the level value of 0.05, it can be concluded that students control class and experimental class come from the same variant population or with another meaning that both class the homogeneous.

3.3 Test Similarity Data Pretest

After knowing the pretest data is normally distributed and homogeneous, then the variance similarity test was carried out. Pretest data similarity test works for see similarity knowledge critical thinking and creative physics students. The variance similarity test was carried out with *multivariate analysis of variance* help application SPSS 25.0 *for windows.* Results test similarity of pretest data showed in the following table.

Table 3.3   Results test Similarity Data Pretest thinking critical and creative

Multivariate Tests [a]						
Effect		Value	F	Hypothesis df	df error	Sig.
Intercept	Pillai's Trace	0.99	1597,304 [b]	2,000	27,000	0
	Wilks ' Lambda	0.08	1597,304 [b]	2,000	27,000	0
	Hotelling's Trace	118,31	1597,304 [b]	2,000	27,000	0
	Roy's Largest Root	118,31	1597,304 [b]	2,000	27,000	0
Class	Pillai's Trace	0.01	.207 [b]	2,000	27,000	0.81
	Wilks ' Lambda	0.98	.207 [b]	2,000	27,000	0.81

	Hotelling's Trace	0.015	.207 [b]	2,000	27,000	0.81
	Roy's Largest Root	0.015	.207 [b]	2,000	27,000	0.81

Based on the table of results of the *multivariate tests* of the pretest data of students critical and creative thinking skills, it was obtained that the F $_{count\ was}$ 1.59 and the significance as big as 0.000 on level < 0.05. Score significance which obtained on critical and creative thinking skills more than 0.05. Based on results concluded that no there is difference early ability science process skills and problem solving skills students in class experiment with class control.
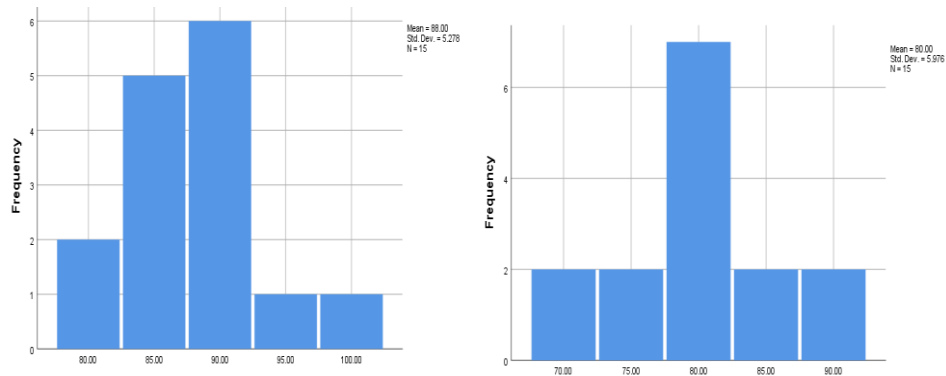
3.4 Test requirements analysis data

Test requirements analysis data more formerly conducted as condition for testing statistics inferential. Test requirements consist from test normality and homogeneity. Test normality use test *Kolmogorov-Smirnov* at a significance level of 0.05 and homogeneity test using the method Levene's test on level significance 0.05, measurement use help application SPSS 25.0 for window. Results summary calculation normality posttest skills process scienceand solving ability problem is shown in the following table.

Table 3.4 Tests of Normality Postest

	Postest Results	Kolmogorov- Smirnov [a]			Shapiro- Wilk		
		Statistics	df	Sig.	Statistics	df	Sig.
Pos-Test Score	Thinking Post Test Critical	0.21	15	0.05	0.90	15	0.11
	PostTest Control Think Critical	0.23	15	0.02	0.90	15	0.11
	Post Drops thinking Creative	0.16	15	.20 [*]	0.93	15	0.33
	Post Drops Control thinking Creative	0.23	15	0.02	0.88	15	0.05

Based on results test normality with test Kolmogrov-Smirnov with $\alpha=0.05$ on table obtained score significance for posttest critical thinking ability in the experimental class is 0.21 and the control is 0.23. Score significance ability creative thinking class the experimental class is 0.16 and the control class is 0.23. Based on the value that the significance obtained from the normality test above is known to be greater of 0.05, it is concluded that the posttest data of science process skills and ability solving problem physics student in on is distribute normal. Chart normality data posttest Skills process science and ability solving problem can also seen in the following figure.

Fig. 3.3 Test Normality Creative
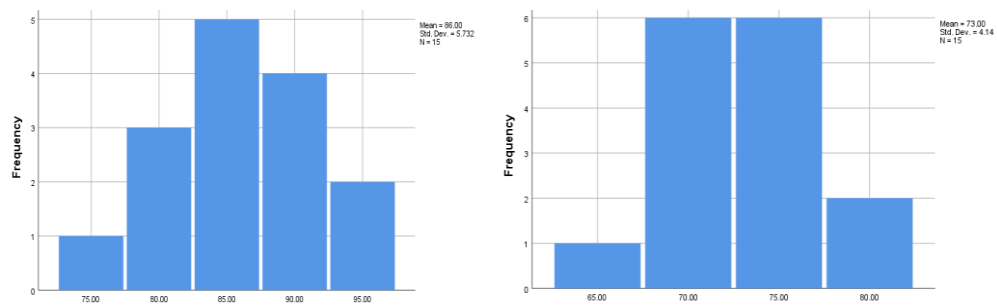
Fig. 3.4 Test Normality Think Critical

3.5 Test Homogeneity Posttest

Test homogeneity on study this use 2 requirements which required conducted before use test analysis manova that is test homogeneity variant covariance and test homogeneity variant. Test homogeneity matrix variant covariance this for see is variable bound think critical and creative second class sample is same. Results from test homogeneity matrix variant covariance this showed on table.

Table 3.5 Box's Text of Equality of Covariance Matrices

Box's Text Matrices [a]	
Box's M	.96
F	.31
Sig.	.81

Results calculation box's test of equality of covariance on table obtained score F that is 0.31 and score sig that is 0.81. Provision condition test homogeneity matrix variant covariance that

is if score sig > 0.05 so H_o received. The significance value obtained based on the calculation is 0.81 > 0.05, it can be concluded that the covariance matrix of the dependent variable is same.

The second stage of homogeneity test is a mandatory requirement before using multivariate analysis (manova), namely the homogeneity test of variance with use Levene's test. Test homogeneity variant for see the variables of science process skills and problem solving abilities are the same for the treatment variables. The results of the homogeneity of variance test are shown in table.

Table 3.6 Test Homogeneity

Levene's Test of Equality of Error Variances [a]

		Levene Statistics	df1	df2	Sig.
Critical Thinking	Based on Mean	0.26	1	28	0.71
	Based on Median	0.04	1	28	0.84
	Based on Median and with adjusted df	0.04	1	27.45	0.84
	Based on trimmed mean	0.10	1	28	0.75
Creative Thinking	Based on Mean	0.12	1	28	0.78
	Based on Median	0.23	1	28	0.63
	Based on Median and with adjusted df	0.23	1	27.05	0.63
	Based on trimmed mean	0.06	1	28	0.80

Based on table obtained results test homogeneity variant with Levene's test have score significance to posttest critical thinking that is 0, 264 and creative thinking that is 0.125 with level $\alpha = 0.05$. The result of Levene's test significance value > 0.05 indicates the variance matrix the covariance on the critical thinking variable and individual creative thinking ability is same for variable treatment. Based on results calculation each test normality and homogeneity to critical thinking and students' creativity is normally distributed and homogeneous. Continue to view the influence and relationship of students' critical and creative thinking in the experimental and control classes used Manova analysis. On study this results calculation analysis manova use help application SPSS 25.0 for windows.

3.6 Influence Model Problem Based Learning help modellus software on students' critical and creative thinking skills.

Test hypothesis first one done in study this includes value data posttest science process skills and ability solving problem physics students. Test process hypothesis using multivariate analysis of variance (manova) with the help of SPSS 25 for windows. Test analysis manova have two stages that is use test multivariate test with use Pillai's Trace test, Wilks ' Lambda, Hotelling's Roy's Largest Root and Test Of Between Subject Effect. Results Pillai's Trace test Wilks ' Lambda, Hotelling's Roy's Largest Root used for see difference influence model problem based learning to Skills process science and ability solving problem physics students. Results test manova Step first showed on table.

Table 3.7 Test Multivariate

Effect		Value	F	Hypothesis df	df error	Sig.
Intercept	Pillai's Trace	0.99	7045,766 [b]	2,000	27,000	0
	Wilks ' Lambda	0.00	7045,766 [b]	2,000	27,000	0
	Hotelling's Trace	521,90	7045,766 [b]	2,000	27,000	0
	Roy's Largest Root	521,90	7045,766 [b]	2,000	27,000	0
Class	Pillai's Trace	0.70	32,422 [b]	2,000	27,000	0
	Wilks ' Lambda	0.29	32,422 [b]	2,000	27,000	0
	Hotelling's Trace	2,40	32,422 [b]	2,000	27,000	0
	Roy's Largest Root	2,40	32,422 [b]	2,000	27,000	0

Results test manova step second that is test between-subject effect for knowing influence model problem based learning to Skills science process and ability solving problem by univariate use test of between-subject effect. Results analysis helped Between subject effects testapplication SPSS 25.0 shown on table.

Based on results test hypothesis Step first use statistical test Pillai's Trace, Wilks' Lambda, Hotelling's Roy's Largest Root test obtained F= 7045 and score 0.000 significance with level 0.05 significance. Score significance < 0.05 then Ho is $_{rejected.}$ Results test manova Step second that is Between-Subjects Effects for knowing the influence of the problem based learning model based on the software modellus to ability think critical and creative students.

Table 3.8 Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Think critically	480,000 [a]	1	480,000	15,101	0.001
	Think creative	1267,500 [b]	1	1,267,500	50,700	0
Intercept	Think critically	211,680,000	1	211,680,000	6,659,596	0
	Think creative	189607.5	1	189607.5	7,584,300	0
Class	Think critically	480,000	1	480,000	15,101	0.001
	Think creative	1,267,500	1	1,267,500	50,700	0
Error	Think critically	890,000	28	31,786		
	Think creative	700,000	28	25,000		
Total	Think critically	213050	30			
	Think creative	191575000	30			
Corrected Total	Think critically	1,370,000	29			
	Think creative	1,967,500	29			

The results of the calculation of the test of between-subject effects are obtainedthe F value for critical thinking is 480 and the F value for critical thinking is 15.10 at a significance level of 0.05. Test results on the test of between subject effect which shows the value of sig < 0.05 then H $_{0\ is}$ rejected and H $_{1\ is}$ accepted which have meaning there is influence which significance

Among class which using a problem based learning model based on modellus software on students' critical and creative thinking skills.

3.7 Percentage Enhancement N-gain

Based on results pretest and posttest found that there are difference average score thinking critical student in class experiment and classcontrol. The difference between the average pretest and posttest scores of thinking critical student so that need determined percentage enhancement N-gain thinking critical. The increase in students' can be calculated with N-gain normalized on second class sample. Something learning said to be more effective if it produces a score *gain* higher with see more students. The results of the percentage calculation enhancement N-gain thinking critical shown on table.

Table 3.9 Percentage Improved N-gain Thinking Critical

Thinking Critical	Pretest	PostTest	Gain %	Category
Class Experiment	46.67	88	41.33	Currently
Class Control	45.33	80	36.75	Low

Based on the calculation of the percent increase in science process skills in experimental class by 55% and in the control class by 41%. Calculation percentage enhancement N-gain Skills process science student on class experiment more tall compared with class control so that could concluded that class experiment could taught use model problem based learning more good compared with class control which taught use learning conventional. Calculation enhancement The next science process skill is analysis per item. This analysis it is useful to see the N-gain on the indicators of students' science process skills from instruments that have been given to the experimental and control classes. Average gain per indicator process skills science showed on table.

Thinking Creative	Pretest	PostTest	Gain %	Category
Class Experiment	45.00	86	41.00	Currently
Class Control	44.00	73	28.67	Low

4. Conclusion

Based on research after conducting quasi-experimental research with two group pretest-posttest designs, the results of the modellus-based problem-based learning model significantly affect students' critical and creative thinking skills. The results of the multivariate analysis of variance pretest critical and creative thinking obtained Fcount = 0.20 and significant = 0.81. As for the posttest Fcount = 32.42 significant = 0.00 at the level of 0.05. The statistical test for the N-Gain of students' critical thinking skills in the experimental class was 41% and the control class was 35%. In the experimental class, the N-Gain of creative thinking skills is 41% and the control class is 29%.

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