

# artikel

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## The development of mathematical problem based on Higher Order Thinking Skill (HOTS) on comparative material by implementing PBL and its effect on the teacher's creative thinking skill

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**Abstract.** Assessing both learning process and achievement is a pedagogical competency in which it refers to an ability that must be possessed by the teacher. The learning done by teacher is intended to maximize the students' higher order thinking skills, that is why the assessment is required to measure their higher order thinking skills. This research was carried out to study the teacher's creative thinking skill and the implementation of problem-based learning to improve teacher's creative thinking skill in creating mathematical problems based on higher order thinking skill (HOTS) through a comparative research. The method used was mixed method combining quantitative and qualitative research methods. 64 respondents were selected as the subject of this research, then they were divided into two classes, an experimental class which involved 32 teachers and a control class which consisted of 32 teachers. This research revealed that there was a significant difference found on the independent t-test from the post-test. Data analysis showed that t-value taken from post-test was sig.  $0,000 \leq 0,05$ , it proved significant. Therefore, there was an effect of the implementation of problem-based learning in which it was able to improve the teachers' creative thinking skill in creating mathematical problems based on higher order thinking skill.

### 1. Introduction

The teacher must possess the competencies covering the ability to make an assessment, both on the learning process and achievement. The teacher is expected to be able to compile Higher Order Thinking Skill (HOTS) questions, in which they are the questions with higher level of cognitive. However, there are many teachers who still do not understand and master the way how to compile the questions, the characteristics of HOTS questions and how to make ordinary questions into HOTS questions. It is important to train the teacher to develop the questions that are included in HOTS.

In conducting the evaluation, especially on the assessment related to cognitive aspect, the teacher needs to develop a variety of instruments from an adequate assessment that are able to find out the students' abilities comprehensively. So far, there has never been a test conducted



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on the quality of questions created by the teacher so that the questions used on the test or even examinations are always the same.

The development of students' mindsets that are increasing rapidly should be followed by the teacher's ability to create questions that are able to find out their high-level of cognitive aspects, like the questions of applying and reasoning. The questions that are able to find out their cognitive level are known as HOTS questions; these types of questions should be mastered by the teacher, so that the students are accustomed to solve the questions that are challenging to their thinking and reasoning. In fact, are many teachers who still do not understand and master on how to compile and develop HOTS questions.

According to [1] higher order thinking skills are the most important aspect in the education process. A person's thought process can affect several aspects, including (1) learning ability, (2) speed and (3) learning effectiveness. Thus, thinking skills are very closely related to one's learning process. Students who are trained to think show a positive impact on the development of their education.

HOTS question is defined as the measurement instruments used to measure higher-order thinking skills covering the ability that is not merely about recalling, restating, or referring without doing the without doing the reciting. HOTS question measures the ability of: a. Transferring one concept to another b. Processing and applying information c. Looking for the relations from various different information d. Using the information to solve problem e. Examining the ideas and information critically.

David R. Krathwohl classifies the cognitive process dimension as follows [12] :

**Table 1.** Structure of the cognitive process dimension of the revised taxonomy

<b>HOTS</b>	Creating	Put elements together to form a novel, coherent whole or make a original product Verbs: Generating, Planning, producing
	Evaluating	Making judgements based on criteria and standards Verbs: checking, Critiquing
	Analyzing	Breaking material into its constituent parts and detecting how the parts relate to one another and to an overall structure or purpose. Verbs : Differentiating, organizing, Attributing
<b>MOTS</b>	Applying	Carrying out using a procedure in a given situation Verbs : Executing, Implementing.
<b>LOTS</b>	Understanding	Determining the meaning of instructional messages, including oral, written, and graphic communication. Verbs : Interpreting, Exemplifying, classifying, summarizing, inferring, comparing, Explaining.
	Remembering	Retrieving relevant knowledge from long-term memory Verbs : recognizing, recalling

According to [2] Creative thinking skills are an alternative way of solving problems because they can improve the quality and effectiveness of problem solving and the results of decisions made. In the learning process, students must be motivated to develop their thinking skills. In the field of mathematics, creativity is often associated with problem solving and submission. The ability to create more different answers to the same problem. So it can be concluded that creativity is the thought process of students who have character and ability in finding many answers to a problem. In [3] it is shown that creative thinking is a thinking skill in realizing the imagination as individual freedom while providing opportunities to get new information through thinking and expressing students' ideas. Then [5] developing a creative thinking process is one of the most commonly used theories to determine the process of

creative thinking which includes four stages including the first stage is the preparation stage, then the second stage is incubation, then the third stage is illumination, and the last stage is the stage verification. Therefore, creativity is not only about products or results, but also about the motivation of creative people to engage in creative thinking processes to produce creative products. Personal aspects are categorized into four aspects, namely (1) aspects of fluency, (2) aspects of flexibility, (3) aspects of originality, and (4) aspects of elaboration [4].

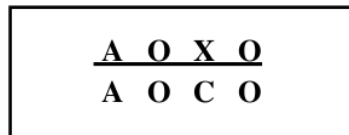
In this research students are expected to have creative thinking skills in proving lemmas or theorems. The indicators in this research are used to determine students' creative thinking skills which are assessed through 3 aspects: first, fluency, then second, flexibility, and finally, novelty. Problem Based Learning (PBL) has been defined by [7] as a strategy when learning and teaching activities take place to develop active learning by giving students control of the process. Learning itself involves the use of open and unstructured problems to trigger learning. PBL is a constructivist learning problem model that helps teachers solve and think about problems. Ben and Erickson in [6] assert that PBL is a learning strategy that involves teachers in solving problems by integrating various concepts and abilities of many transdisciplines. This strategy includes gathering and synthesizing information, and presenting findings. PBL has been widely adopted in the fields and context of education to promote critical thinking and problem solving in authentic learning situations.

The learning implementation can be done by using learning tool which refers to the model of PBL can be used to see the teacher creative thinking based on the indicators found in creative thinking ability. This research was intended to study the teacher's creative thinking ability and the implementation of PBL in making HOTS questions. Based on the explanation above, the researcher needed to implement further research. Therefore, the researcher conducted research entitled Developing HOTS-based mathematics questions in comparative material and its effect on the teacher's creative thinking ability as well as the implementation of PBL.

## 2. Research Methods

The method used in this study is a new method that was introduced in 2018, which is a mixed method. It said a mixed method because in the process of combining two methods are very well known, namely qualitative methods and quantitative methods. The process uses sequential explanations in which quantitative data is collected first then followed by qualitative data that can explain the findings from quantitative data (for example, after assessing pragmatic competence at the group level, following up on some participants to gain an understanding of their characteristics) [9] and [10] apply this model to their research.

In this study plans to organize two class groups, namely the experimental class and the control class whose samples are taken randomly and examined using pre-test and post-test using the following design.



With the following information:

- O : Pretest / Postes (Dependent Variables observed)
- C : Control of treatment
- X : Treatment given (Independent Variable)
- A : Random sampling

In this design, the research was conducted in an experimental class. Before conducting the research, the experimental class was given a pre-test to know their initial ability. During the research, the experimental class received a treatment by using PBL (X). Then, in the end of the research, the class was given a post-test to see the result of the treatment given. The design

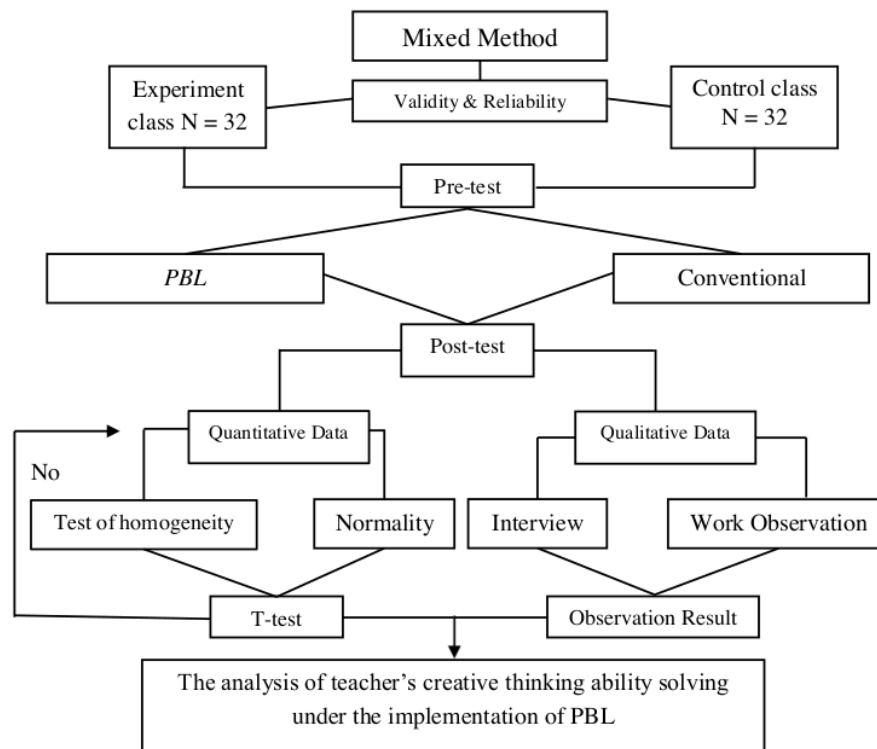
to see the effect of the treatment (independent variable) on the difference or improvement of dependent variable observed.

**Population**

This research was implemented to the teachers of subject teacher's deliberations or *Musyawah guru mata pelajaran (MGMP)* of mathematics in Madrasah working group of MTs Negeri 9 Kencong or *Kelompok kerja madrasah (KKM) MTs Negeri 9 Kencong* in Jember. The sampling technique used was random sampling conducted by randomly choosing two classes, the first class was the experimental class where PBL was implemented consisting of 32 teachers and the second class was the control class with the implementation of conventional learning consisting of 32 teachers

**Instrument**

There are several instruments used in this study, namely (1) tests, (2) observations, and (3) interviews. The figure below is a combination of research methods with research procedures consisting of two stages based on the stages of the research procedure: preliminary studies (qualitative research), analysis of critical thinking and implementation of PBL (quantitative research). Explanation of the procedure is illustrated as follows:



**Figure 1.** The Model of Mixed Method

### Task

1. Ani's house and her school is 400 m far. If Ani's house and her school is drawn 10 cm on the map, what is the scale of the map?  
Explanation: The question above is HOTS question with easy category because in solving the problem there needs comparative ability.
2. A wheel has a radius of 16 with the distance of each radius of 8 cm. If the distance of the radius is changed into 10 cm, how many radiuses can be attached in the wheel?  
Explanation: the question above is a HOTS question with moderate category because to solve the problem, the students need to recall the formula of circle, then followed by determining the possible number of radius that can be attached.
3. You are one of 25 committees of *iftar* at the mosque near your house. It is predicted that there will be 1000 people who attend. The dinner menu will be given after *Maghrib* Prayer up to *adzan Isya'* is heard. Make the maximum strategy when *adzan Isya'* echoes!  
Explanation: The question above was categorized as difficult HOTS question, because to answer the question, the students must be able to remember and understand the materials of factual, conceptual and procedural, by analyzing the situation (stimuli) given to the students to be able to determine the strategy.

The teacher's creative thinking was assessed based on the indicators that had been converted into the assessment instruments. The aim of this task was to create higher-order thinking skills-based mathematical questions in the comparative material.

Quantitative method was used to analyze the teacher's ability after the problem-based learning method was applied. Qualitative method was used to analyze the data from the observation and interview of the selected teacher. This research investigated two variables namely the implementation of PBL which belonged to independent variable and the teacher's creative thinking ability from the making of higher order thinking skills-based questions.

In this study the research hypothesis test used is independent sample t-test with a significance level of 5% or 0.05 where is the creative thinking ability of students who use PBL is lower than or equal to the creative thinking ability of students who do not use PBL and is the creative thinking abilities of students who use PBL are higher than the creative thinking abilities of students who do not use PBL.

With the following information:

- If  $p_{value} < 0.05$  then reject  $H_0$  and accept  $H_1$
- If  $p_{value} \geq 0.05$  then accept  $H_0$  and reject  $H_1$

### 1. Research Finding

This research was conducted in the experimental class and the control class that had been determined using the two methods previously described, namely the qualitative method to determine the creative thinking ability of the teacher. The research implementation was carried out after the validity and reliability test of the instrument was carried out. Then, the experimental and control classes were given a pre-test to determine the ability of early creative thinking.

After conducting the pre-test in the experimental and control classes, then the learning processes were done in the experimental classes by using PBL and the control classes by using conventional learning, then the data were obtained and analyzed by using SPSS application. Here are the results of data analysis by using SPSS application and excel.

### 1.1 Validasi Instrumen

Before showing the results, it needed to test the reliability and validity of the pre-test and post-test assessment instruments. The following table shows the results of validity and reliability.



**Table 2.** The test result of the validity instrument Correlations

		NO_1	NO_2	NO_3	NO_4	Total
NO_1	Pearson Correlation	1	-.046	.036	.203	.366*
	Sig. (2-tailed)		.807	.848	.273	.043
	N	31	31	31	31	31
NO_2	Pearson Correlation	-.046	1	.317	.238	.527**
	Sig. (2-tailed)	.807		.082	.197	.002
	N	31	31	31	31	31
NO_3	Pearson Correlation	.036	.317	1	.333	.855**
	Sig. (2-tailed)	.848	.082		.067	.000
	N	31	31	31	31	31
NO_4	Pearson Correlation	.203	.238	.333	1	.638**
	Sig. (2-tailed)	.273	.197	.067		.000
	N	31	31	31	31	31
Total	Pearson Correlation	.366*	.527**	.855**	.638**	1
	Sig. (2-tailed)	.043	.002	.000	.000	
	N	31	31	31	31	31

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

\*\*. Correlation is significant at the 0.01 level (2-tailed).

Based on the table, it can be seen that the value of from the number 1 was 0.366, number 2 was 0.527, number 3 was 0.855, number 4 was 0.638. All items resulted with N = 31, so all items were valid.

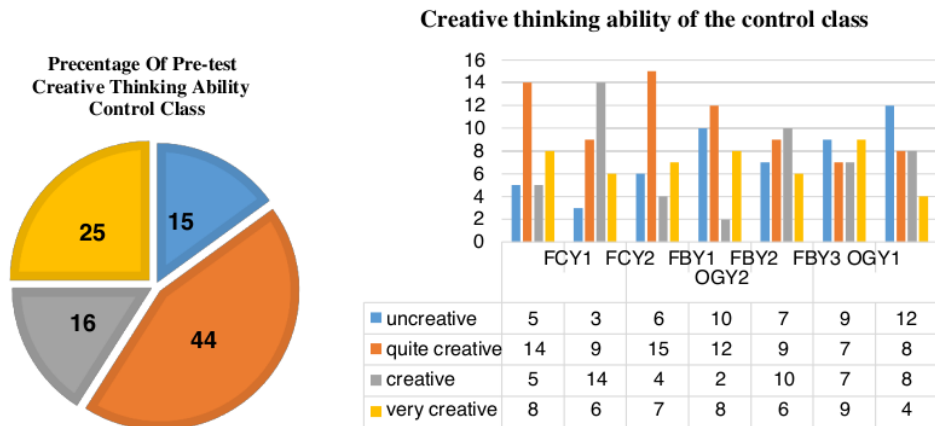
**Table 3.** The test result of the reliability question

Reliability Statistics	
Cronbach's Alpha	N of items
.459	4

Based on the table, it can be seen that the value of whole reliability was 0.459 and from the significance level of 5% with  $dk = N - 1 = 30, = 0.459$ . Therefore, . This concluded that the instrument items were reliable.

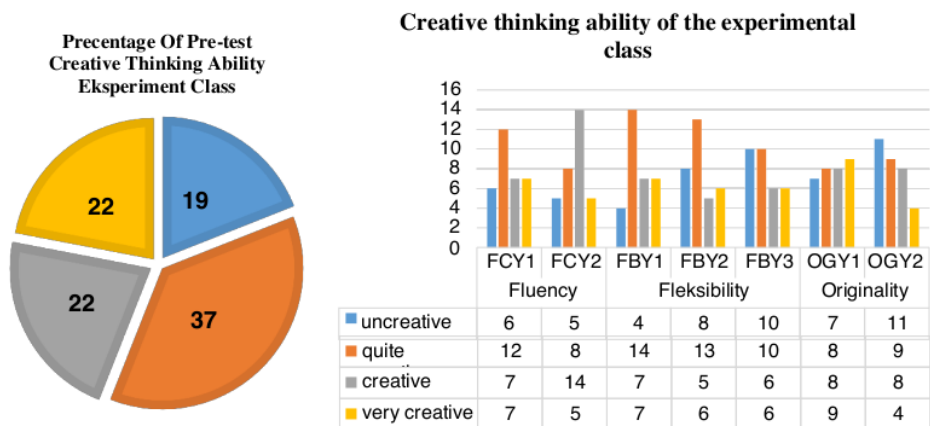
### 3.2 Result

The preliminary study was done with 32 teachers in the control class to find out their creative thinking ability levels. 32 subjects were tested with pre-test (diagram 1), in the control class, it was found that 15% belonged to not creative category, 44% of the teachers belonged to less creative category, 16% belonged to creative category and 25% of the teachers belonged to very creative category.



**Diagram 1.** The Distribution of Pre-test of student Creative Thinking Ability in the Control Class

The research was done with 32 teachers of the experimental class to find out their creative thinking ability. 32 subjects were tested with pre-test (diagram 2), in the experimental class, it was found that 19% of the teachers belonged to not creative category, 37% belonged to less creative category, 22% belonged to creative category and 22% of the teachers belonged to very creative category.



**Diagram 2.** The distribution of Pre-test of student Creative Thinking Ability in the experiment class.

The data analysis used quantitative statistics for variances to find out the difference of PBL implemented. The data analysis used SPSS application with the data from the results of learning achievement of the pre-test. Based on the table 2, the homogeneity test got the result of sig. 0.130. This was significant if it was higher than 0.05 (based on the mean = 0.130 > 0.05), therefore the data variants were the pre-test from the control class and Homogeneous experimental class



**Table 4.** Test of Homogeneity of Variances

Value			
Levene Statistic	df1	df2	Sig.
2.352	1	62	.130

From the data of the pre-test implementation in the experimental and control classes it was found that the data variance was homogeneous. Then the independent t-test was performed significantly if the value of sig. greater than 0.05. Sig value (2-tailed) based on the mean= 0.888 > 0.05. Ho was accepted, there was no difference in the pretest mean values of the control and the experimental classes.

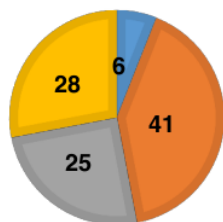
The implementation of further research was to carry out conventional learning, then post-tests were conducted. The research was conducted on 32 teachers in the control class to determine the level of creative thinking skills after learning. 42 subjects were tested with Post-test (diagram 3), in the control class, 6% were in the non-creative category, 41% were in the less creative category, 25% were in the creative category and 28% of the teachers were in the very creative category.

**Table 5.** Independent Samples Test

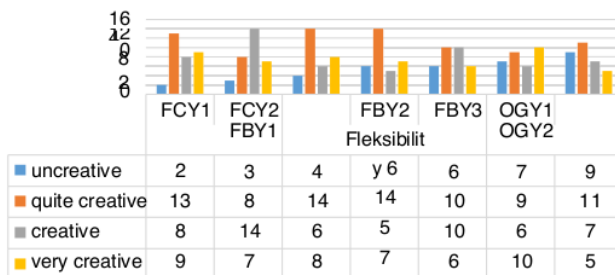
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
Value									Lower	Upper
Equal variances assumed	2.352	.130	.1	62	.888	.062	.444		-.825	.950

**Diagram 3.** The distribution of Post-test of student Creative Thinking Ability in the Control

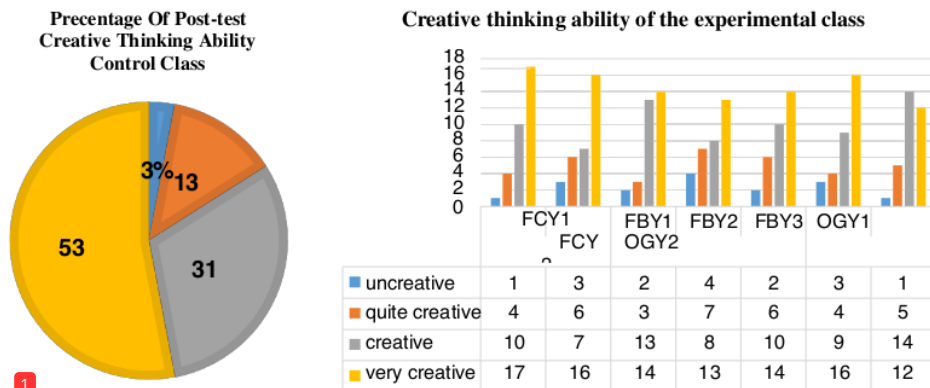
Percentage Of Post-test Creative Thinking Ability Control Class



Creative thinking ability of the control class



The implementation of further research by carrying out learning by using problem-based learning model, then post-tests were conducted. The research was conducted on 32 teachers in the experimental class to determine the level of creative thinking skill after learning. 32 subjects were tested by Post-test (diagram 4), in the experimental class it was found that 3% of teachers were in the non-creative category, 13% were in the less creative category, 31% were in the creative category, 53% of the teachers were in the very creative category.



**Diagram 4.** The distribution of Post-test of student Creative Thinking Ability in the experiment class

Normality test analysis was done on the post-test results. The data distribution will be said to be significant if the value is greater or equal to 0.05. Table 6 shows the significant value of the experimental class was  $0.107 \geq 0.05$  and the control class was  $0.114 \geq 0.05$ . So this means that the data from both classes were normally distributed.

**Table 6.** Tests of Normality

	Kolmogorov-Smirnov <sup>a</sup>			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	df	Sig.
<b>Control</b>	.140	32	.114	.948	32	.125
<b>Eksperiment</b>	.141	32	.107	.950	32	.141

a. Lilliefors Significance Correction

Data on the post-test implementation in the experimental class and the control class have been found, data from both classes are normally distributed. Then an independent t test was carried out, based on table 7 showing Sig. (2-tailed) based on the mean = 0,000 < 0.05 Ho is rejected, there are differences in the average value of the pretest of the control class and the experimental class.

Seen from table 7 the post-test implementation data, in the experimental class and the control class are normally distributed. Because the data is normally distributed then an independent t-test is performed, based on table 7 which shows Sig. (2-tailed) based on an average of 0,000 < 0,2 then H0 is rejected and H1 is accepted. The conclusion obtained is that the posttest results between the control class and the experimental class have significant differences after the implementation of learning with PBL. The experimental class has an average of 45,23 while the control class has an average of 41.31 which means that the average results of the Creative Thinking Ability of the experimental class students are higher than the average results of the Creative Thinking Ability of the control class students and show that learning is based the problem has a greater influence. On students' combinatorial thinking skills significantly.

**Table 7. Independent Samples Test**

		Levene's Test for Equality of Variances		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
Value	Equal variances assumed	.262	.611	-12.4	74	.000	-4.656	.373	-5.402	-3.910

1 Distribution of observations from PBL carried out in the experimental class with 45 teachers. Based on Diagram 5, it was found that 49% of teachers were very active in PBL, 34% of teachers were in the active category, 9% were in the quite active category, 13% were inactive and 3% were very inactive. It means, PBL can have effect on making HOTS-based math problems on comparative material.

**The Distribution of Student Activities During PBL Implementation**



1 **Diagram 5.**The observation result distribution of all subject in the experimental class

#### 4. Discussion

The findings of the use of creative thinking in finding systematic solutions to ensure that all possibilities have been proven. In the view of creative thinking, is a special aspect of mathematical thinking [8]. In line with this research, it was conducted to analyze the ability to think creatively and the application of problem-based learning in order to maximize their creative thinking skills. Previous studies regarding the application of PBL have been carried out in students [11], then this research has found the learning achievements of teachers.

In the control class was found that 3% of teachers were in the non-creative category, 13% were in the less creative category, 31% were in the creative category, 53% of the teachers were in the highly creative category. In the experimental class was found that 3% of teachers were in the non-creative category, 13% were in the less creative category, 31% were in the creative category, 53% were in the very creative category. The results of the independent sample test analysis showed that the learning achievements applied to the teacher at the pre-

test stage were not different and at the post test stage the different analysis tests showed significant value ( $p \leq 0.05$ ) which means that the post learning had different results.

1

### **5. Conclusion**

The research that has been done showed that the application of PBL had a significant effect on the teacher's creative thinking skills in the experimental class. The teachers in the experimental class showed their creative thinking skills compared to the control class. The results showed that the improvement on teachers' learning achievements and the ability to think creatively was seen from the post-test.

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