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# Combining scientific approach and PBL in learning of set to improve mathematical creative thinking skills

# Combining scientific approach and PBL in learning of set to improve mathematical creative thinking skills

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**Abstract.** The purpose of this research is to determine the improvement of students' creative thinking through a scientific approach that integrated a problem-based learning model on set problems. This research used quasi-experimental design which compared pretest and posttest results between two groups. The population of this study was all of the eighth-grade students at one of state Islamic junior high schools (MTsN) in Sungai Penuh, Jambi, Indonesia. The research sample consisted of students in two groups that were randomly selected. One group was an experimental group that treated by a scientific approach integrated with PBL and the other one was as a control group that treated by direct instruction. We collected the data using a test of students' mathematical creative thinking skills. Then, we analyzed it statistically using the N-gain parameter for the test results. The results of the analysis show that the improvement of students' creative thinking through the scientific approach that integrated with PBL was better than the improvement through the direct instruction. Learning with a scientific approach combined with PBL makes the students freer to express their ideas and to improve their creative thinking skills.

## Introduction

Individual mastery level in mathematics determines the survival and progress of civilization. Basically, that is not just master the mathematics as mere scientific knowledge, but creativity in mathematics is needed to understand the world around and today's life and to succeed in the future [1, 2]. Based on 2013-Curriculum, mathematics learning in schools aims to improve students' creativity. Student learning creativity in mathematics is more than the creative thinking. In mathematics, creative thinking is a combination of logical thinking and divergent thinking that emphased to flexibility, fluency, and novelty [3].

In fact, students' creativity in learning is difficult to form because mathematics learning at school has not been motivate students to involved directly the construct their mathematical knowledge. Students are more dependent on the teacher so the characteristic of students has not been left to grow and develop through their learning styles [4]. Students memorize existing theorems or formulas without knowing or understanding the concept of the formulas or theorems. So, the students' skills on solving problems are only imitate the steps that have been given previously [5]. Students have difficulty to solve the problems about creativity because they are not commonly given the problems that make they think creatively [6].

The learning done so far is the direct instruction learning model. By the conventional/direct instruction model, the teacher more active than with students. Whereas expected by 2013-Curriculum, students must be more active than teachers, and the teacher's job is to guide, motivate, and direct students [7]. The learning process makes students less independent in learning, so students find it difficult to develop their knowledge and are not creative in thinking because they rely on the role of the teacher so that when faced with questions that lead to student creativity, it is difficult to do it [8]. This makes students' creative thinking low. The learning process did not facilitate students to generate many ideas, elaborate on an answer, and give birth to new or unique expressions/answers.

An alternative that can be done by teachers to improve students' creative thinking is scientific approach. The scientific approach can develop mathematical creative thinking and student learning independence [9, 10]. In the scientific approach, there are 5 stages of learning, namely observing, asking, gathering information, associating (reasoning), and communicating [11, 12]. These activities are characteristic of the stages of the scientific approach which are then called 5-ing activities.

The application of a scientific approach requires a model that is in line with it [13] like problem-based learning model (PBL). The PBL model as a constructivist learning method oriented to student-centered learning can foster creative, collaborative, metacognitive thinking, develop higher-order thinking skills, increase understanding of meaning, increase independence, facilitate problem-solving, and build teamwork [14–16].

The steps of PBL can facilitate students to improve their creative thinking. Students as problem solvers was encouraged to be able to find problems and elaborate it to submit the plan of solutions. Students are also facilitated to explore various alternatives of completion through data gathering and distributing. At the end, students are trained to present the findings and reflect how effective their ways to solve the problems [17]. This study aims to determine the increase of students' creative thinking and the differences of students' skills who using a scientific approach combined with PBL and the other one who using direct learning.

## 2. Method

This research is a quasi-experimental research with a randomized control group pretest-posttest design as presented in Table 1 [18]. The population in this study is all of the seventh-grade students in MTsN 2 Sungai Penuh that consist of two groups. Randomly, VII A was selected as an experimental group that was treated a scientific approach integrated with PBL model and VII B was selected as a control group that was treated direct instructional learning.

**Table 1.** Randomized control group pretest-posttest design

| Group | Pre-test | Treatment | Post-test |
|---|---|---|---|
| Experiment | $T_1$[a] | X[b] | $T_2$[c] |
| Control | $T_1$[a] | | $T_2$[c] |

[a] Pre-test
[b] The treatment given to the experimental class by applying scientific approach combined with the PBL model.
[c] Post-test

This research use test to find out students' mathematical creative thinking. The mathematical creative thinking test is given as written test questions that consisting of five questions in pre-test and post-test. The test has been prepared according to learning indicators and mathematical creative thinking indicators. The pretest is used to determine the students' initial creative thinking before learning. While the posttest is to find out the final students' creative thinking after learning. N-Gain is used to find out the improvement of mathematical creative thinking from both experimental groups.

Before conducting a hypothesis test, normality and homogeneity tests are tested as a prerequisite for testing a hypothesis. The normality test is used to determine whether a population is normally distributed or not. The test uses the Liliefors test. The homogeneity test is used to determine whether

the distribution of sample data has a homogeneous variance or not because the sample consists of two groups, then the F-test is used. Hypothesis testing is used to prove the presumptions or hypotheses proposed in this research, namely to determine the differences of students' skills in mathematical creative thinking that used a scientific approach that is combined with PBL and the other that used a direct instructional learning.

## 3. Result and discussion

### *3.1. Mathematical creative thinking improvement*

The initial tests and the final test results in both groups were compared. The difference between the final test score and the initial test score is expressed as a normalized gain or N-gain. N-gain value is used to determine the category of improvement in students' mathematical creative thinking abilities in both groups before and after treatment. Data on the difference in the pretest and posttest scores of students in experimental groups are presented in Figure 1.

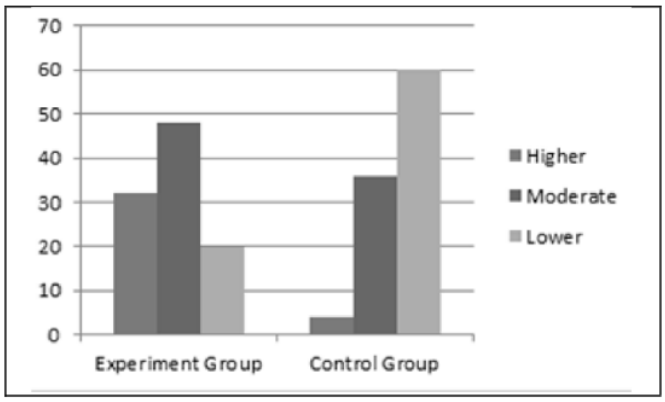


**Figure 1.** N-Gain values of students' creative thinking abilities

In Figure 1, the difference of N-gain value is quite striking in the acquisition of low and high categories. In the experimental group, respectively 32% and 48% of students were in high and moderate ability and only 20% of students in the low category. Whereas in control groups, 60% of students in the low category, 36% of students in the moderate category, and only 4% of students in the high category. The experimental group was dominated by students with high N-gain value. While, the control group was dominated by students with medium and low N-gain value. In addition, differences in creative thinking in the two sample groups are also indicated by differences in the average N-gain. The experimental group has an average N-gain value of 0.6, which is in the medium category. While, the control group has an average value of N-gain of 0.3, which is in the low category.

The differences in treatment given in two groups affect differences in students' skills improvement in creative thinking. Students in the experiment group are treated as a scientific approach that is integrated with PBL model. The learning steps implemented begins with orienting students to the problem. In this step the teacher introduces learning material through questions so that makes students motivated to find answers to the problems presented, this will make students stimulated to think more creatively [19, 20]. The next step in learning facilitates the students to ask the teacher or other students. In this step, thinking more creatively to prepare as many questions as possible required. This makes students' skills to think creatively, especially on indicators of flexibility [21].

In the individual and group inquiry step, the teacher guides students to gather detailed information about the problem from various sources, raises new ideas to solve the problem, and uses available information to formulate solutions to problems [22]. This stage is the most dominant in improving students' creative thinking through three activities, namely (1) detailing information to find solutions

to problems as one aspect of creative thinking skill on fluency indicators; (2) bring up new ideas as a way of developing creative thinking skill on novelty indicators; and (3) think of many ways to solve problems to develop or practice creative thinking on indicators of flexibility [23].

In the fourth step of learning which is developing and communicating, students are required to be more creative in developing information so that it can be accepted by the teacher and other students, or in other words, the truth is believed. In communicating information, students must use more creative thinking in compiling information to create many solutions and load new information [24]. In the final step, analysis, and evaluation, the information conveyed by other students must be analyzed in such a way because it is not certain that all the information conveyed is true. Analyzing activities also involve students creatively to distinguish detailed information that is acceptable (true) or not [25].

Instead, the learning process in the control group used direct instructional or conventional model. In the preliminary activities, the teacher conveys the learning objectives and motivates students. Then the teacher explains the material with the lecture method while students record the material given by the teacher. The dominant role of the teacher rather than the student does not stimulate the level of students' skills, especially in creative thinking. Next, provide exercises to students according to the examples that have been explained before. At the end of learning, students are given an individual assignment [26]. In the control group with direct instruction learning, the teacher's role is more active than that of students. This learning is less independent of students to learn so students find it difficult to develop their knowledge and are less creative in thinking skills. As a result, the students will get difficult when they are confronted with questions that guide the ability to think creatively, generate many ideas, elaborate on an answer and give a new or unique expressions/answers. In other words, their creative thinking are low [27].

### *3.2. Students' mathematical creative thinking improvement comparison*

Besides the N-gain values, the comparison students' skills improvement in creative thinking is also shown by a hypothesis test or t-test. Before conducting a hypothesis test, certainly, the two-sample groups are normally and homogeneously distributed. The normality test result by the Kolmogorov-Smirnov test can be seen in Table 2.

**Table 2.** The results of the normality test

| | Classes | Kolmogorov-Smirnov[a] | | |
|---|---|---|---|---|
| | | Statistic | df | Sig. |
| Score | Pre-test of experiment group | 0.148 | 25 | 0.162 |
| | Post-test of experiment group | 0.121 | 25 | 0.200* |
| | Pre-test of control group | 0.131 | 25 | 0.200* |
| | Post-test of control group | 0.159 | 25 | 0.104 |

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Based on Table 2, the Sig. value in the two groups was greater than 0.05. It means that the results of students' mathematical reasoning skills are distributed normally at a 95% confidence level. After the normality test, the homogeneity test of the two sample groups shown in Table 3.

**Table 3.** The results of the test of variance homogeneity

| | | Levene Statistic | df1 | df2 | Sig. |
|---|---|---|---|---|---|
| Score | Based on mean | 1.967 | 3 | 96 | 0.124 |
| | Based on median | 1.824 | 3 | 96 | 0.148 |
| | Based on median and with adjusted df | 1.824 | 3 | 86.114 | 0.149 |
| | Based on trimmed mean | 1.983 | 3 | 96 | 0.122 |

According to Table 3, all Sig. > 0.05. It means the variance of both groups were homogeneous. The normality test and homogeneity test results indicated that data of the two groups are distributed normally and homogeneous and the hypothesis test can be done with the t-test.

**Table 4.** The results of the 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 |
| Score | Equal variances assumed | 2.317 | 0.135 | -6.724 | 48 | 0.000 | -5.880 |
| | Equal variances not assumed | | | -6.724 | 41.295 | 0.000 | -5.880 |

According to Table 4, the t-test results obtained 0.000 < Sig. (0.05). This means that $H_1$ is accepted so that it can be concluded that the students' skills improvement creative thinking using a scientific approach combined with PBL models was better than the same skills improvement in other classes that using direct instruction or conventional learning at 95% confidence level.

As explained earlier, the treatment as different learning processes that are given to the sample groups causes different creative thinking improvement. By these approach and learning model, students are introduced to the problem so it stimulates their creative thinking to solve the problem, collect information, analyze and communicate the information they get creatively in many ways or interpretations, and detail an answer/information even looking for new information to solve the problems presented [28]. Students are involved in the learning process actively to obtain and develop their knowledge so that students can learn independently and be more creative in solving the problems they face [29, 30]. In contrast to conventional learning, the students do not facilitate to improve these skills.

## 4. Conclusion

The study showed the average N-gain value of students' mathematical creative thinking in the experimental group is 0.6 (moderate category) or in the higher category. It was higher than the control group's which is only 0.3 or in the low category. Besides, the results of the hypothesis test indicate that students who used a scientific approach combined with PBL have mathematical creative thinking improvement which was better than students who used direct instruction or conventional learning have. Therefore, researchers recommend secondary school mathematics teachers to use a scientific approach combined with PBL as an effort to improve students' mathematical creative thinking. The research in improving the other higher-order thinking skills through this approach and learning model can be an interesting study for future researchers.

## Acknowledgment

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