Improving Students’ mathematical creative thinking ability through problem-based learning

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Abstract. Creative thinking ability is one of the capabilities needed to face various situations and problems in life, students should have this ability. This study aims to know the effectiveness of the use of problem-based learning method in improving students' creative thinking ability. This study used a mixed method research with explanatory sequential design. This method began with the use of quantitative methods by implementing pretest and posttest to find out the average normalized gains of the students' creative ability, and then followed by interviews to find out more about their experience in using problem-based learning and its effectiveness in improving the ability of creative thinking. The result is an increase of students' creative thinking ability by using problem-based learning model, with mean pretest rate (19.9) and posttest (71.4), and normalized gain score of 0.856, the increase is in high category. Interview results show that problem-based learning is useful and can accommodate creative thinking ability, as it also provides flexibility to improve other cognitive abilities.

1. Introduction
Creative thinking is an essential ability in daily life [1] because it can make people more flexible, open, and can adjust easily to various situations and problems. Creativity is conceptualized as a different thinking or creative expert performance [2]. Creative thinking ability is one of the learning objectives listed in the Law Number 20 of the Year 2003 on National Education System. Creative thinking ability is one of the necessary skills in the world of work.

The students score for mathematical thinking process courses still needed to be improved. There were still many students who scored below the standard, In the academic year 2016/2017, only 31% of students who met the standard, the rest had not met the standard. Results of analysis on the pattern of students’ answers showed that most students were able to answer theoretical problems, but not applicative and explorative problems. This showed that the ability of students was still at the theoretical level, this ability to apply concepts and this ability to think creatively were still poor.

One of the alternatives to improve the students' creative thinking ability is by applying the Problem Based Learning (PBL) model which gives an opportunity for learners to make effective and to explore their thinking ability [1,3]. PBL allows the student's creative thinking process to increase, as it requires students to elaborate every information from a given problem, to develop a solution strategy, execute the strategy, and evaluate it. Giving a problem to students is one way to familiarize them with creative thinking and on the process of mathematical thinking for a solution strategy, students are required to use...
their creative thinking skills. Therefore, this research was conducted to find out (1) whether there were significant differences in students mathematical creative thinking skills before and after using the PBL learning model; (2) whether there was an increase in students’ mathematical creative thinking skills after using the PBL learning model; and (3) how was students’ attitude towards the PBL learning model.

2. Methods
This research is a mixed method research that combines quantitative and qualitative studies with explanatory sequential design. This method begins with the use of quantitative methods with data collection techniques in the form of tests that are analyzed by using the t test, and then interviews are analyzed descriptively [4].

![Figure 1. The explanatory sequential design.](image)

Subjects of this research were 25 students of the Department of Mathematics Education of Pasundan University who were taking a course on mathematical thinking process.

3. Results and Discussion

3.1. Results
Results of pretest and posttest data were analyzed to determine the differences in students’ creative thinking skills before and after using the PBL model. Results of descriptive data analysis, normality, and t-test data analysis using SPSS version 22 are as follows:

|                | Mean  | Std. Deviation | Std. Error | Kolmogorov-Smirnov | T    | Sig. (2-tailed) |
|----------------|-------|----------------|------------|--------------------|------|-----------------|
| Pretest        | 19.9200 | 10.68847     | 2.13769   | .123               | -.200* | .000            |
| Postest        | 71.0400 | 4.48590      | .89718    | .117               | -20.914 | .000            |

Based on Table 1, it can be seen that the average pretest and posttest are 19.92 and 71.04 respectively. There is an increase of 51.12. To find out the average differences in average and whether the increase is significant or not statistical testing was carried out. In the Kolmogorov-Smirnov test, Sig> 0.05, thus the data is normally distributed. Then proceed with the t test paired Samples Test. The 2-tailed Sig value = 0.000 is smaller than 0.05, so Ha is accepted, meaning that there are significant differences in students’ mathematical creative thinking skills before and after using the PBL learning model.

To find out whether there is an increase in students’ creative mathematical thinking skills after using the PBL learning model, one-sample test was carried out. In Table 2 it is known that the sig (2-tailed) value = 0.000 is smaller than 0.05, so Ha is accepted, meaning that there is a significant increase in students' mathematical creative thinking ability after using the PBL learning model.
### Table 2. One-sample t test

| T     | Df | Sig. (2-tailed) | Mean Difference | 95% Confidence Interval of the Difference |
|-------|----|-----------------|-----------------|------------------------------------------|
| Creative Thinking | 7.956 | 24 | .000 | .13480 | .0998 | .1698 |

In addition to using the t test, the average normalized gain was also calculated by using the Normalized Gain Formula \( g \) [5], 
\[
g = \frac{(\text{posttest score} - \text{pretest score})}{(\text{maximal ideal score} - \text{pretest score})} = \frac{(71.04 - 19.92)}{(80 - 19.92)} = 0.851. 
\]
Based on normalized gain criteria in Table 3, the increase is found to be in the high category.

### Table 3. Normalized Gain Criteria

| \( g \) (Normalized Gain) | Interpretation |
|---------------------------|----------------|
| \( g > 0.7 \)             | High           |
| \( 0.3 < g \leq 0.7 \)   | Medium         |
| \( g \leq 0.3 \)         | Low            |

To find out how is students’ attitude towards PBL learning model, interviews were conducted with 4 students who had received mathematics learning using the PBL method with results as follows: (1) on their view of mathematics learning using problem-based learning, the first student state that it was exciting, he liked to use the PBL because it cooperate and deliver an opinion. The second student answered that it was right, but not all subjects could use PBL, it would have to be adapted to the material and condition of the students. The third student argued that it was very good so that students could know the actual benefits of mathematics in real life. The fourth student holds that problem-based learning can be applied in learning mathematics, and could make students more active in learning; (2) 75% of students did not have difficulties in understanding the material by using problem-based learning, 25% of students found it difficult because they understood more if explained by the lecturer; (3) 100% of students agreed that problem-based learning could accommodate the ability to think and provide flexibility to improve cognitive and affective abilities because PBL demands thinking creatively and actively in solving problems, students can also share with fellow friends about the material [7-8].

3.2. Discussion

The test results showed an increase (high category) of students' creative thinking ability resulting from using the Problem Based Learning model. Referring to a general understanding of creative thinking, a person has creative thinking ability when the person is accustomed to building a new idea or idea smoothly and flexible in solving math analytics problems correctly [6]. Similarly, 100% of students agree that problem-based learning can accommodate the ability to think and provide flexibility to improve cognitive and affective abilities because PBL demands thinking creatively and actively in solving problems, students can also share with fellow friends about the material [7-8].
The results of comparisons of studies on the effectiveness of PBL conclude that the effectiveness of PBL is generally consistent in demonstrating benefits in long-term knowledge retention and application of knowledge [9].

Based on the results of interviews one of the lack of PBL is that is takes a long time, this is in accord with the results of research conducted by Ari on 42 teachers in which, 26% of teachers examined stated that PBL spent much time before and after learning [8].

4. Conclusion

Based on the analysis of research results and discussion, the following is conclude: there is an increase in creative thinking ability of students who received problem-based learning. The increase is at a high level.

5. References

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