Mathematical creative thinking ability and problem centered learning

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Abstract. This research aims to determine the improvement of students' mathematical creative thinking ability through Problem Centered Learning (PCL) approach. This research is a quasi-experimental with a non-equivalent research design. The population of this research were the eighth-grade students of SMP Negeri in Bandung. The sample of this research was determined by purposive sampling. The sample consisted of 62 students who were divided into two classes, experimental class and control class. The experimental class uses the PCL approach, while the control class uses conventional learning. Each class consists of 31 students. The data of students' mathematical creative thinking ability were obtained by using test techniques. The improvement was proven by n-gain value of students' pre-test and post-test. The conclusions obtained from the data analysis and discussion, there is a significant difference in the improvement mathematical creative thinking ability between high EMA in the PCL group and medium EMA in conventional learning. Based on EMA, PCL can be applied in high EMA classes. While students with medium and low EMA need further research so that students' mathematical abilities can be improved by PCL.

1. Introduction

Creative thinking is an ability that needs to be developed in order to fulfill the challenges and needs of nowadays. Mathematics learning related to needed concepts for solving mathematical problems and knowledge in other scopes. Creative thinking is a process which someone can find out a new relationship from a different perspective and consider as spontaneous process, it can happen internally and unpredictable [1]. Some aspects of creative thinking ability such as are an ability to identify problems, constructing various and original ideas, also checking and assessing the relationship between choices. Students can change their thinking patterns creatively by finding new ways for solving a problem. Students can find a new relationship, improving and discussing previous ideas. Students can become
creative by creative thinking, not only thinking but also in positive activities [2]. Research conducted by Munandar in 1997 showed elementary and junior high school students having the same creativity as predictor intelligence of learning achievement [3]. This is suitable with the results of research namely that student creativity affects student learning achievement. If the student's learning achievement is low, one of the factors is student creativity and it can be said that student creativity is low [4].

The ability of creative thinking is an ability of work field. Competencies are needed in work today namely: (1) having confidence, (2) having motivation in achievement, (3) mastering basic skills (reading, writing, computing, listening, speaking, computer skills), (4) having expertise in a particular field, (5) having thinking skills (identifying and solving problems, making decisions, analytically and logically thinking, creating new ideas or products by creating thinking), (6) having interpersonal skills in team and negotiating. These skills also must be had by Indonesian students for competing globally in the future. The improving development of Indonesian student potential, especially creative thinking is needed so they have high competitiveness in creating a new idea for the nation progress [5].

Several previous studies have shown that the creative thinking ability of junior high school students is still in the low category [6], [7], [8]. The results of a preliminary study conducted at a junior high school in Bandung obtained a description that the students are less of creative thinking questions abilities. Most of students only find single answer, so the students’ creative thinking ability is still relatively low. The other information based on the preliminary study of junior high school students usually do routine questions while non-routine questions rarely do related to creative thinking skills. Based on several studies and the results of the preliminary studies above, it is necessary for furthermore research on in improving students’ mathematical creative thinking abilities. One of the learning approaches for developing thinking skills is using the Problem Centered Learning (PCL) approach.

PCL gives three important abilities for students in learning namely; students are taught in solving problems, students are required in thinking, and cooperating in groups. In this learning the teacher and students work together, developing other perspectives in solving a problem. There no Students are worry doing something wrong instead they can find new ideas from the teacher or other students in solving a problem [9], [10]. Some previous studies have concluded that PCL can develop students’ mathematical abilities such as adaptive reasoning, mathematical communication and student learning achievement [11], [12], [13]

2. Method
This research aims to enhance students' mathematical creative thinking ability with the PCL approach in terms of the students' EMA. The EMA of students is determined based on the previous midterm scores which are then grouped into high, medium, and low EMA categories. This ability improvement is seen from the n-gain students’ scores which obtained from the pretest and posttest scores. This research is a quasi-experimental with non-equivalent control group design. The research was conducted at a Junior High School in Bandung. The population was all students of class VIII. The sampling technique was used purposive sampling. The selected sample is students of class VIII-G as the experimental group and VIII-H as the control group. Each group consists of 31 students. The data in this research is score of students' mathematical creative thinking ability. Data collection is done by tests with mathematical creative thinking ability test instruments. The instruments are arranged based on indicators of mathematical creative thinking ability. The indicators are 1) students can find various solutions and answers to a problem, 2) students can show various ways to solve a problem, 3) students can afford
unique answers, different from others, 4) student are able to specify an object. Data was analyzed using statistical tests quantitatively, namely the Two Ways Anova test.

3. Result and Discussion
Data on students' mathematical creative thinking ability is grouped based on students' EMA. Determination of students EMA is done by calculating the average and standard deviations of midterm scores. The average and standard deviation are calculated by combining the score of the two sample groups, so that the average \( \bar{x} = 60.76 \) and the standard deviation \( s = 18.04 \). EMA distribution of students can be seen in the following Table 1.

| EMA          | Control | Experiment | Total |
|--------------|---------|------------|-------|
| High         | 7       | 5          | 12    |
| Medium       | 17      | 21         | 38    |
| Low          | 7       | 5          | 12    |
| Total        | 31      | 31         | 62    |

After classifying students based on EMA, the next step is to determine the n-gain score of students' mathematical creative thinking ability. It is obtained by comparing the difference between the posttest and pretest scores with the difference between the ideal and pretest scores. Furthermore n-gain students are classified based on the criteria of the n-gain score as stated by Hake [14]. The average n-gain of students' mathematical creative thinking ability based on the EMA in each group can be seen in the following Figure 1.

![Figure 1](image_url)

**Figure 1.** Average n-gain Mathematical Creative Thinking Ability Based on EMA

After classifying the students' EMA, the data was analyzed by the Two Ways Anova test. The prerequisite tests are the normality and homogeneity test of students' n-gain which are done before a hypothesis test. After testing the normality and homogeneity at the significance level \( \alpha = 0.05 \), the results obtained that the distribution of n-gain mathematical creative thinking ability are normal and
homogeneous. Therefore, hypothesis testing is performed using the Two Ways Anova Test to determine differences in students' mathematical creative thinking ability. The test criterion is to reject $H_0$ if $\text{sig} < 0.05$, otherwise there is not enough evidence to reject $H_0$. Recapitulation of the results of the Two Ways Anova calculation for the improvement of students' mathematical creative thinking ability can be seen in the following Table 2.

Table 2. Recapitulation Results Two Wayss Anova test of N-Gain
Mathematical Creative Thinking Ability

| Factor         | df | $F$  | $\text{Sig}$ | Conclusion   |
|----------------|----|------|--------------|--------------|
| Group          | 1  | 6.446| 0.014        | $H_0$ rejected |
| EMA            | 2  | 3.874| 0.027        | $H_0$ rejected |
| Group*EMA      | 2  | 0.693| 0.504        | $H_0$ accepted |

The EMA factor in Table 2 shows that the $\text{sig.} = 0.027 < \alpha = 0.05$ so $H_0$ is rejected. This means that the improvement mathematical creative thinking ability of students who get learning with the PCL approach is significantly different compared to students who get conventional learning in terms of students' EMA. This shows that the EMA factor has a significant influence on improving students' mathematical creative thinking ability. The significance value of the Group*EMA factor is $0.504 > \alpha = 0.05$, the conclusion is not enough evidence to reject $H_0$. This means that there is no interaction between learning approaches and EMA on students' mathematical creative thinking ability. The absence of interaction effects indicates that PCL has the same effect on students with high, medium, or low EMA. The n-gain curve of mathematical creative thinking ability based on the factors of learning approach and EMA can be seen in the following Figure 2.

Figure 2. Correlation Curves of Mathematical Creative Thinking Ability based on Learning Factors and EMA

Based on Figure 2, it appears that students with high, medium, and low EMA on the PCL approach have higher n-gain scores than students in conventional learning.
Table 3 is presents post hoc scheffe test data of improvement mathematical creative thinking ability in each of the high, medium, and low EMA categories between PCL approach and conventional learning. Post hoc scheffe test was chosen because of the large amount of the data in each category.

**Table 3. Post Hoc Scheffe Test Results Mathematical Creative Thinking Ability between High, Medium, Low EMA**

| Group EMA (I)     | Group EMA (J)          | Mean Difference (I-J) | Sig.  | Conclusion       |
|-------------------|------------------------|-----------------------|-------|------------------|
| High PCL          | Medium PCL             | 0.16370               | 0.728 | Accepted H₀      |
|                   | Low PCL                | 0.33360               | 0.177 | Accepted H₀      |
|                   | High Conventional      | 0.21893               | 0.636 | Accepted H₀      |
|                   | Medium Conventional    | 0.34302*              | 0.045 | Rejected H₀      |
|                   | Low Conventional       | 0.34877               | 0.140 | Accepted H₀      |
| Medium PCL        | High PCL               | -0.16370              | 0.728 | Accepted H₀      |
|                   | Low PCL                | 0.16990               | 0.626 | Accepted H₀      |
|                   | High Conventional      | 0.05523               | 0.996 | Accepted H₀      |
|                   | Medium Conventional    | 0.17932               | 0.163 | Accepted H₀      |
|                   | Low Conventional       | 0.18507               | 0.534 | Accepted H₀      |
| Low PCL           | High PCL               | -0.33360              | 0.177 | Accepted H₀      |
|                   | Medium PCL             | -0.16990              | 0.626 | Accepted H₀      |
|                   | High Conventional      | -0.11467              | 0.958 | Accepted H₀      |
|                   | Medium Conventional    | 0.00942               | 1.000 | Accepted H₀      |
|                   | Low Conventional       | 0.01517               | 1.000 | Accepted H₀      |

Based on Table 3, it can be seen that the significance value between high EMA in the PCL group and medium EMA in the conventional group is 0.045 < α = 0.05, the conclusion H₀ is rejected. This means that there is a significant difference in the improvement in mathematical creative thinking ability between high EMA in the PCL group and medium EMA in conventional learning.

Meanwhile, as shown in Table 3, for differences in the improvement mathematically creative thinking ability of students who obtain conventional learning, there is no significant difference between students with high, medium, and low EMA. This can be seen from the significance value for the conventional learning that is more than 0.05, thus the conclusion H₀ is accepted. This means that there is no significant difference in the increase in mathematical creative thinking abilities between high, medium and low ability students in conventional learning. Likewise, students who obtained learning using the PCL approach, among high, medium, and low EMA, the significance value showed that all of them were more than 0.05 so that H₀ was accepted. Means there is no significant difference in the improvement of mathematical creative thinking ability between high, medium, and low EMA in the PCL approach.

Based on the results of data analysis, it shows that there is no interaction effect of learning approaches and EMA on students' mathematical creative thinking ability. That is because there is no significant difference in the improvement of mathematical creative thinking ability between students with high, medium, and low EMA who obtain conventional learning, and also there is no significant difference in the improvement in mathematical creative thinking ability between high, medium, and low EMA with the PCL approach.

Improvement the mathematical creative thinking ability students who received conventional learning with high EMA did not differ significantly between students who obtained PCL approach. Students with
high EMA can develop ways of thinking flexibly both with conventional learning and with PCL approach.

In the PCL approach students with high EMA develop their way of thinking from the given problems. They are required to look at problems from different points of view, trying to develop divergent thinking in solving problems. Students with high EMA certainly have more mathematical knowledge compared to other students. Group learning in the PCL approach, students with high EMA guide students with medium and low EMA, they consider the ideas of other friends in solving problems. By giving an explanation to his friends, high EMA students also reflect on their own answers, by negotiating with other students can improve their level of thinking. They try to find other strategies in solving problems, and convey the results of their thoughts to other students through class discussions.

In PCL and conventional learning the teacher gives scaffolding to students who experience a deadlock when solving a problem. The teacher gives direction to students through questions that can build students' way of thinking in solving problems. It helps effectively improve mathematical creative thinking ability that obtains PCL approach and conventional learning. In conventional learning, students was learned by memorizing concepts, formulas or following the problem-solving procedures taught by the teacher.

These description appropriate with Lithner [15] "rote learning is in itself not problematic, contrary, memorizing facts and procedures, even without understanding, is a central aspect of mathematics learning". He said that it does not make sense to expect students to understand every mathematical idea, because at least there are mathematical ideas that are too difficult to fully understand and simply learn by memorizing with a little understanding. Problems arise if learning mathematics by memorizing dominates learning so that it can inhibit the development of other mathematical abilities. So basically learning by memorizing is part of learning in mathematics. It can also support students in developing mathematical abilities as well as mathematical creative thinking ability.

The students with medium and low EMA have not significant difference improvement in mathematical creative thinking ability between students who obtained the PCL approach and students who obtained conventional learning. In the PCL approach, students with medium and low EMA get the advantage from group learning. They can learn from students with high EMA. Students with medium EMA get the opportunity to learn from students with high EMA, and they can also provide explanations to students with low EMA how to solve problems.

4. Conclusion
The conclusions obtained from the data analysis and discussion, there is a significant difference in the improvement mathematical creative thinking ability between high EMA in the PCL group and medium EMA in conventional learning. Based on EMA, PCL can be applied in high EMA classes. While students with medium and low EMA need further research so that students' mathematical abilities can be improved by PCL.
5. References

[1] Suryadi D 2012 *Membangun budaya baru dalam berpikir matematika* (Bandung: Rizqi Press)
[2] Sumarmo U 2013 *Berpikir dan disposisi matematika serta pembelajarannya* kumpulan makalah (Bandung: FMIPA UPI)
[3] Munandar U 2012 *Pengembangan kreativitas anak berbakat* (Jakarta: Rineka Cipta)
[4] Machromah I U & Usodo B 2016 Analyze of The Creative Thinking Level of Students Junior High School Viewed from Mathematics Anxiety *Proceeding of 3rd International Conference on Research, Implementation and Education of Mathematics and Science, Yogyakarta* 16 – 17 May
[5] Career Center Maine Departmen Labour 2004 *Today’s work competencies in Maine* [online]. Available on: http://www.maine.gov/labor/cwri/publications/pdf/EssentialWorkCompetencies.pdf [accessed on Juni 2016]
[6] Rohaeti E E 2008 *Pendekatan dengan pembelajaran eksplorasi untuk mengembangkan kemampuan kritis dan kreatif matematik siswa SMP* (Dissertation SPS UPI: unpublished)
[7] Nurhafsari A 2015 *Meningkatkan kemampuan berpikir kreatif matematis dan kemandirian belajar siswa SMP melalui penerapan aktivitas quick on the draw dalam pembelajaran kooperatif* (Thesis SPS UPI: unpublished)
[8] Budiman A 2015 *Peningkatan kemampuan pemecahan masalah, berpikir kreatif dan habits of mind siswa SMA melalui pendekatan creative problem solving* . (Thesis SPS UPI: unpublished)
[9] Kadel S 1992 Problem-centered learning in mathematics and science. *Hot Topics: Usable research* (Washington DC: SouthEastern Regional Vision for Education)
[10] Wheatley G H 1991 Constructivist Perspectives on Science and Mathematics Learning. *Science education* 75(1): 9-21
[11] Yunaz F 2013 *Pengaruh pendekatan Problem Centered Learning terhadap peningkatan kemampuan penalaran adaptif siswa SMP* (Thesis UPI: unpublished)
[12] Machmud T 2013 *Peningkatan kemampuan komunikasi, pemecahan masalah matematis, dan self-efficacy siswa SMP melalui pendekatan Problem Centered Learning dengan strategi scaffolding* (Dissertation SPs UPI: unpublished)
[13] Imamah D N, Hobri & Arika I K 2015 Penerapan model pembelajaran problem centered learning (PCL) untuk meningkatkan hasil belajar siswa pokok bahasan operasi hitung bentuk aljabar siswa kelas VII A semester ganjil di SMPN 14 Jember TA 2013/2014 *Pancaran, 4* (1), page. 183-192
[14] Hake R R 1999 *Analyzing change/gain score* Department of Physics Woodland Hills USA: Indiana University
[15] Lithner J 2012 Learning mathematics by creative or imitative reasoning *12th International Congress on Mathematical Education, 8 – 15 July, COEX, Seoul, Korea*

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