Challenging students to improve their mathematical creativity in solving multiple solution task on challenge based learning class

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Abstract. As one of the competencies that must be possessed in the era of Industry 4.0, creativity also plays an important role for development of mathematics education in the 21st era. This study aims to determine the improvement of students' mathematical creativity in solving Multiple Solution Task (MST) on Challenge Based Learning (CBL) class. The quantitative quasi experimental pretest posttest conducted at SMP Negeri 1 Semarang used a mathematical creativity test adopted MST as a data collection technique and data were analyzed using the t-test hypothesis and gain. The results revealed the improvement of students' mathematical creativity in solving MST after the implementation of CBL and differences in the improvement of students' mathematical creativity where the student’s gain of mathematical creativity on CBL (experimental) class was more than the student’s gain of the mathematics of the Problem Based Learning (PBL) (control) class. Other findings indicate a difference in achievement of mathematical creativity indicators between the CBL class and PBL class which shows that CBL provides a positive influence to improve each indicator of mathematical creativity.

1. Introduction
Many things must be prepared to hail industrial era 4.0. One of them is the challenge to prepare qualified human resources who have qualified competencies, abilities and skills. One of them is creativity. Creativity is one of the competencies and qualifications that must be owned by people in the industrial era 4.0 [1-3]. Creativity is challenge that needs to be fulfilled in Economics [1] as well as qualifications in IT and production job [2]. Hecklau, et al [4] added that flexibility as the one indicator of creativity [5-8] is one of the competencies that must be developed human resources as personal competence.

Creativity does not only play an important role in math learning itself and math problem solving process [8] but also becomes one of the essence of learning in the 21st era in several countries in the world [9]. In Bloom's Taxonomy, creativity places the highest cognitive level in Create [10] and in its development with critical thinking, problem solving, connection, mathematical reasoning, and metacognitive can develop into high order thinking skills [11,12]. Mathematics learning without involving creativity as well as override student’s ability, especially gifted students because develop talent requires creativity in exploring mathematical problem solving.
The many studies of creativity that already exist, but not an easy thing to reveal fundamental definitions related to creativity. Vygotsky mentions creativity as one of the important mechanical activities in the construction of new knowledge that comes from long and unconscious aesthetic incubation and selection processes that turn into conscious perceptions [7,13,14]. Creativity itself is a personal and social trait that fosters human development at all levels and points of life [15] and it’s a product of creative thinking activities that can generate and produce new ideas [16,17]. Mathematical creativity has characteristics in various ways by solving non-algorithmic problems and having a close relationship with divergent thinking and being flexible in looking at a problem [8] or can be said as a combination of logical and divergent thinking [17].

There are many ways to identify mathematical creativity, one of which is Multiple Solution Task (MST). MST is not only as a tool for the evaluation of relative creativity [18] but also an assignment that contain an explicit requirement for solving a problem in multiple ways [19]. MST can be derived from within the geometric topic as well as in this research but not also from different mathematical topics [20]. To identify mathematical creativity in MST can be done by determining the results of the students’ answers by looking their fluency, flexibility, and novelty [18,19] which these components are three aspects of creativity that disering called The Torrance Test of Creative Thinking [5]. Kadir, Lucyana, & Satriawati [21] briefly explain the differences of these indicators as developing ideas (fluency), different ideas (flexibility), and new ideas by changing their thinking (novelty). Levenson [8] added fluency can be measured as the total number of ideas produced students, flexibility can be evaluated to establish the difference solution every exit strategy, while the novelty of the solution based on the level of insight and conventional accordance with the level of student understanding in this case the student can produce a novelty. From identifying creativity in solving problems, students not only can you become fluent in building many problems from a person situation, but they can also develop flexibility with them generate many solutions to a problem.

To develop creativity it is necessary to choose strategies, approaches, methods, and techniques that involve many active learning students, both mentally, physically, and socially, which are intended to grow creative mathematics learning goals as well as teacher's ability using the right learning model, varied, good teaching and using good questions [22]. One of the learning model that can be developed is Challenge Based Learning model that can be described as a special form of problem-based learning where the problems are realistic and natural [23]. Challenge Based Learning provides an efficient and effective framework for learning and solving real-world challenges [24]. This framework is collaborative and direct, asking all participants (students and teachers) to identify Big Ideas, submit Good Questions, discover and overcome challenges, gain deep knowledge, develop 21st century skills, and share their thoughts with the world. This learning aims to help students find ways to present and or solve problems [25].

| Class | VIII E | VIII F | VIII G | VIII H | VIII I |
|-------|--------|--------|--------|--------|--------|
| Mean of Creativity | 62.94 | 41.06 | 62.83 | 52.86 | 54.42 |
| Total Mean | 54.90 |

The study of the results of student creativity has been carried out by several researchers. TIMMS study in 2011 states that only 2% of Indonesian students can work on high and advanced categories and 15% of students can only work on intermediate category questions [26]. The results of the preliminary study presented in Table 1 state that the average value of student creativity was still relatively low. This was because the average creativity of students in each class only reaches intervals of values 40 to 65 with a total average of 54.90. Based on these data, it is indicated that the creativity of students is still classified as poor.

From the problem described above, this study takes the main headline about students' creativity in solving MST on CBL class. This study aims to determine the improvement of student’s mathematical creativity in solving MST on CBL class. The improvement of student's mathematical creativity was
assessed by difference in pretest and posttest on CBL class and gain difference of experimental class (CBL) and control class (PBL).

2. Research Methods
Quantitative study of quasi experimental pretest posttest held at SMP 1 Semarang in April - May 2018 with population was students of class VIII in the academic year 2017/2018. From 5 classes, it was selected one experimental class with CBL model and one control class with PBL models. The data collection technique in this study is a test with analysis of t-test hypothesis and gain to know the improvement of student’s mathematical creativity. Mathematical creativity test which was developed adopting the Multiple Solution Task developed by Levav-Waynberg & Leikin [19].

3. Results And Discussion
CBL class was implemented properly according to CBL sintax, i.e Big Idea, Essential Question, The Challenge, Solution Action, and Assessment. During learning, students were given problem solving experiences with various solution as MST to develop their mathematical creativity. Then, students are tested using MST to explore their mathematical creativity and the impact of CBL to mathematical creativity.

Table 2. The Result of Prerequisite Test

|                      | Kolmogorov-Smirnov | Levene Test |
|----------------------|--------------------|-------------|
| Pre-Post             | Sig. 0.381         | Sig. 0.816  |
| Conclusion           | Ho Accepted        | Ho Accepted |
| Gain                 | Sig. 0.527         | Sig. 0.362  |
| Conclusion           | Ho Accepted        | Ho Accepted |

Before testing the hypothesis, the prerequisite test is carried out beforehand which consists of the Normality Test and Homogeneity Test by SPSS as presented in Table 2. Based on the results of the Kolmogorov-Smirnov Test, the Sig. value of Pre-Post data was 0.381 > 0.05 and the Sig. value for Gain data was 0.527 > 0.05. Thus Pre-Post and Gain data are normally distributed. Based on the results of the Levene Test, the Sig. value of Pre-Post data was 0.816 > 0.05 and the Sig. value of Gain data was 0.362 > 0.05. Thus the Pre-Post and Gain Data are homogeneous. Because the data are normally distributed and homogeneous, a comparative hypothesis test can be done by t-test.

Table 3. The Result of Difference of Pretest and Posttest

|                  | Pre Test | Post Test |
|------------------|----------|-----------|
| Mean             | 62.94    | 82.89     |
| t-score          | 13.09    |           |
| t-table          | 1.67     |           |
| Conclusion       | Ho Rejected |            |

Based on Table 3, it was obtained mean pretest and mean posttest of student’s mathematical creativity were 62.94 and 82.89. The results were tested by t-test then that was obtained $t_{score} = 13.09$ and $t_{table} = 1.67$. Therefore $t_{score} = 13.09 > 1.67 = t_{table}$, then Ho rejected. It could be concluded that mean posttest of mathematical creativity was more than the mean pretest mathematical creativity on solving MST. The results indicated that CBL can improve student’s mathematical creativity. Similarity, Ardiansyah, Asikin & Junaedi [27] showed the effectiveness of CBL on creative thinking skills which is seen from classical and individual completeness and mean difference where mean of student’s creative thinking skills in CBL model was better than mean of student’s creative thinking skills in cooperative learning model. In developing solutions, students can also be encouraged to think creatively in designing solutions [23,24].
Based on Figure 1, there was a significant improvement in each indicator of creativity, especially in flexibility. In fluency aspect, there was an increase of 27% with 56% for pretest and 83% for posttest. In flexibility aspect, there was an increase of 86% with 0% for pretest and 86% for posttest. In novelty aspect, an increase of 19% with 0% for pretest and 19% for posttest. These results indicate that CBL has a positive influence on improving each indicator of creativity. Johnson & Adams [23] added that almost 88% of students agree that CBL experiences makes them creative people.

Table 4. The Result of Gain in Experimental Class and Control Class (in %)

|                  | Control Class | Experimental Class |
|------------------|---------------|--------------------|
| Mean             | 36.24         | 50.48              |
| t_{score}        | 2.89          |                    |
| t_{table}        | 1.67          |                    |
| Conclusion       | Ho Rejected   |                    |

Based on Table 4, it was obtained gain of student’s mathematical creativity on control class and experimental class were 36.24 and 50.48. The results were tested by t-test then that was obtained t_{score} = 2.89 and t_{table} = 1.67. Therefore t_{score} = 2.89 > 1.67 = t_{table}, then Ho rejected. It could be concluded that gain of student’s mathematical creativity on experimental class was more than gain of student’s mathematical creativity on control class on solving MST. The results indicated that there was difference in improvement student’s mathematical creativity between CBL class and PBL class. On other research, CBL was able to improve the professionalism of students, skills and abilities of entrepreneurs for students of design, management, and computer engineering [28], CBL can increase student motivation and effective at lectures students majoring in engineering (Engineering Academy) [29-33].

Based on Figure 2 below, there was a difference in achievement for each indicator of creativity in experimental class and control class, especially in flexibility. In fluency aspect, there was an increase of 8% with 75% for control class and 83% for control class. In flexibility aspect, there was an increase of 30% with 56% for control class and 86% for control class. In novelty aspect, an increase of 19% with 0% for control class and 19% for control class. Thus student’s mathematical creativity on CBL class was better than student’s mathematical creativity on PBL class for achievement mathematical creativity indicators. This results had similarities with Junita [34] who mentioned that
there was achievement and improvement of creative problem solving abilities of students who learn with the CBL approach was better than students who study with the scientific approach.

![Graph of Mathematical Creativity Indicators](image)

**Figure 2.** Graph of Mathematical Creativity Indicators on Experimental and Control Class

In CBL class, student were challenged to create an ideas to solve the problem as well as. During learning, student were given the Big Idea which student will solve as learning objectives. From the Big Idea, will rise the Essential Questions and the Challenges that integrated in a task that explicitly required students to provide varied answers or different solutions. This challenges can trigger students to think creatively by trying to generate new ideas, experiences, failures, and feedback on spatial learning [24,35] which will then produce their mathematical creativity.

Other research stated that CBL effective on science, mathematics, technology, engineering and other learning. Beside of Ardiansyah, Asikin & Junaedi [27] who stated the effectiveness of CBL on creative thinking ability, Cheung, Cohen, Lo, & Elia [36] also stated that CBL also effective in cybersecurity learning. CBL was also an effort to produce students with vocational competencies and soft skills, and use technology and facilities intelligently to solve problems [37]. This was due the learning outcome of CBL were ability to innovate and creativity, self-confidence, self-productivity, self-responsibility, self-direction, and student’s belief [23,35].

4. Conclusion
Based on results and discussions, it can be concluded that there was an improvement student’s mathematical creativity in CBL class which was seen from mean differences of student’s mathematical creativity in pretest and posttest where mean posttest was more than mean pretest and gain differences of student’s mathematical creativity in CBL class and PBL class where gain in CBL was more than gain in PBL. Other findings state that a significant improvement for each mathematical creativity indicators and achievement differences of mathematical creativity indicators in CBL was more than PBL class. This result indicated that CBL has a positive influence on creativity as whole and each indicators of creativity. Researchers suggest to implementing CBL in class to enhance creativity as well as other mathematical abilities and can be used as a references for the development or further research with information technology assistance or blended learning.

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