Mathematical creative thinking ability of students in treffinger and brain-based learning at junior high school

by Kristina Wijayanti

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Abstract. The purpose of this experiment was to comprehensively examine whether innovative Brain-Based Learning and Treffinger learning was effective for developing mathematical creative thinking ability at junior high school. The research design was a quasi-experimental non-equivalent control-group design. The population was all grade VIII students at Junior High School in the 2019/2020 school year. The samples were two classes determined by a randomized class. Data collection techniques with tests. Data analysis were using the z-test and the t-test. The results of this study were the percentage of students in the class that applied the Treffinger learning achieved classical completeness and the mean of creative thinking ability of students in the class that applied the Treffinger learning was more than the mean mathematical creative thinking ability of students in the class that applied Problem-Based Learning. The percentage of students in the Brain-Based Learning class achieved classical completeness and the mean mathematical creative thinking ability of students with Brain-Based Learning was higher than the students with Problem-Based Learning. There is no significant mean difference between the students' mathematical creative thinking ability in the class that apply Brain-Based Learning and Treffinger learning. This research concludes that innovative learning Brain-Based Learning and Treffinger learning is effective for developing mathematical creative thinking ability at junior high school.

1. Introduction

21st-century skills are characterized by 4C characteristics, namely communication, collaboration, critical thinking and problem solving, creativity and innovation. The term “creativity” is often referred to as the novelty of the work of mathematicians. Therefore, at the school level, mathematics problem solving tasks often require student creativity. There is no consensus about defining creativity [1]. Creative ideas are something that are considered new by certain groups [2]. Creativity is the result of a creative individual thinking process. The characteristics of a creative individual are being able to see things from various perspectives with a new approach [3]. Mathematical creative thinking ability is a thought process to create or find unusual ideas that produce a variety of new solutions to open problem but the truth is acceptable. In measuring creative thinking with the indicator of fluency, flexibility, and originality, some studies used problem solving as an instrument asking for non-unique solutions and non-unique solution method [4], [5]. In problem-solving situations, Torrance recommended fluency, flexibility, originality, and elaboration to measure mathematical creative thinking ability [6]. The indicators for fluency in this research was (1) being able to state what was given, being able to express the information on questions; (2) generate relevant answers; accuracy in answering questions; indicators for flexibility were (1) accuracy in applying the formula; (2) providing alternative answers in a variety of ways / more than one way; indicators for originality were (1) using their own way of writing the solution; (2) provide a different solution in general; and indicators for elaboration were (1) obtaining solutions to problems by way of detailed ideas; (2) make a final conclusion from the problem.

Suarez et al. revealed that the brain controls starting from holistic concepts, creativity, analysis, implementation, processing, and training in mind and language awareness [7]. Brain-Based Learning is learning that is scientifically completed that is aligned with how the brain works in carrying out learning. This learning focuses more on pleasure, considers the naturalness of the brain, does not focus on order so that a love of learning arises. Brain-Based Learning can be used in learning because it emphasizes activities that develop the brain in the long term so that it has a long memory in the brain, therefore Brain-Based Learning can be useful for learning at a higher level [8]. Brain-Based learning stages are: (1) pre-presentation; (2) preparation; (3) initiation and acquisition; (4) elaboration; (5) incubation and inserting memory; (6) verification; (7) celebration and integration.

One of the learning models specifically designed with learning phases that generate creative thinking skills is Treffinger learning model [9]. Treffinger learning stages are basic tools, practice with the process, working with real problems. Basic tools or techniques for level I creativity include divergent thinking skills and creative techniques. Fluency, flexibility, and a willingness to come up with different ideas can be developed with these basic techniques. The skills learned in the first stage are applied in feasible situations in the stage of practice with the process. These practices in the first two stages are followed by working with real problems, in which students use their ability to solve problems and use the information obtained in their lives. The benefits that can be obtained from applying this model include (1) fluency in solving problems; (2) have more than one answer idea; (3) dare to have new answers; (4) applying the ideas made through discussion; (5) writing down problem-solving ideas; (6) adjust to the problem by identifying the problem.

Research on the creative thinking ability has been conducted by, among others, Mulyono et al, Ardiansyah, et al, Purwasih et al, Munahefi, and Ismunandar et al. Mulyono et al researched mathematical creative thinking skills based on cognitive styles using Knisley's learning model [10]; Ardiansyah et al conducted research on mathematical creativity in multiple solution tasks [11]; Purwasih analyzed creative thinking skills based on gender differences [12]; Munahefi analyzed creative thinking skills based on self-regulation learning [13], and Ismunandar et al examined creative thinking skills through a realistic mathematics education approach [14]. Research on Treffinger learning has been conducted by, among others, Maulana et al to analyze mathematical literacy skills; and Ahmad tested the effect of Treffinger's learning on self-regulation [15]; while Handayani developed tools to improve creative thinking through the Treffinger learning [9]. Research on Brain-Based Learning has been conducted by, among others, Dewi and Zahid, Suarez, and Waree. Dewi and Zahid revealed mathematics reasoning through Brain-based Learning [16]; Suarez found about brain-control [7]; whereas Waree found the advantage of Brain-Based Learning for learning at higher level [8].

Preliminary study showed that Problem-Based Learning has been implemented but student achievements have not been encouraging. Students' mathematical creative thinking ability is still low. The factors that make the students' mathematical creative thinking abilities low, namely: (1) students prefer to memorize formulas without understanding the use of these formulas; (2) student interest and motivation are low.

This study aims to examine whether innovative Brain-Based Learning and Treffinger learning were effective for developing mathematical creative thinking ability at junior high school. The effectiveness indicators here are the achievement of classical completeness and the mean of mathematical creative thinking ability in the class that applied Brain-Based learning or Treffinger learning is more than that applied Problem-Based Learning (PBL). The Brain-Based Learning is more effective for developing the mathematical creative thinking skills of junior high school students than the Treffinger learning if the creative thinking abilities of students in the class that applied Brain-Based Learning achieves classical completeness and the mean of mathematical creative thinking ability in the class that applied Brain-Based Learning is more than that applied Treffinger learning.

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2. Methods

The design of this study was a quasi-experimental non-equivalent control-group design. The population was 256 students of grade VIII Junior High School in the 2019/2020 school year. The sampling technique in this study was a randomized class technique. Two classes as experimental classes that each class implemented Brain-Based Learning and Treffinger Learning. One class was a control class that applied Problem-Based Learning. The test instrument is in the form of an essay test, arranged based on the material and adjusted to the indicators of mathematical creative thinking, and is used to measure the effectiveness of students' mathematical creative thinking ability after learning. Testing the instrument was carried out to obtain validity, reliability, difficulty level, and different power of the instrument. Data collection techniques used test. Data were analyzed by the z-test, the t-test, and the Mann-Whitney test.

3. Results and Discussion

3.1. Mathematical Creative Thinking on Brain-Based Learning and PBL

The Kolmogorov-Smirnov test gave Sig.=0,078 > 0,05 for the class that applied Brain-Based Learning, so that Ho was accepted. It meant the data of mathematical creative thinking ability of the class that applied Brain-Based Learning came from a population that was normally distributed. Then, the z-test for $\alpha = 5\%$, x = 28, n = 32, and $\pi_0 = 0{,}745$ gave the $z_{count} = 1{,}688$ and the $z_{table} = 1{,}64$. In this case, we concluded that the students' mathematical creative thinking ability achieved classical completeness.

The Shapiro-Wilk test results the significance value of the class that applied Brain-Based Learning and PBL was Sig. = 0.112 > 0.05, so that Ho was accepted. It meant the data of mathematical creative thinking ability of the class that applied Brain-Based Learning and PBLcame from a population that was normally distributed. Levene test obtained the significance value Sig.= 0,708 > 0,05, so that Ho was accepted, that was the variance of the classes that applied Brain-Based Learning and the PBL are homogeneous. The result of the t-test was Sig. = 0,00 < 0,005 so that Ho was rejected. It meant the mean of students' mathematical creative thinking in the class that applied Brain-Based learning was more than that applied PBL.

In PBL, teachers create a learning environment in such way that students are responsible for their knowledge in a real-world context [17]. While Brain-Based Learning contains learning steps, namely pre-presentation, preparation, initiation and acquisition, elaboration, incubation and memory entry, verification, celebration, and integration. In the pre-presentation and preparation stages, students pay attention to the teacher's explanation of the learning objectives and briefly discuss the material. In the initiation and acquisition stages, students discuss finding concepts and exchanging ideas through group activities in completing worksheets. Brain-Based Learning equipped with worksheets can improve learning outcomes. This is in line with Brain-Based Learning affects students' understanding [18] and mathematical communication skill [19]. One of the factors that affect students' learning outcome in class conditions. The atmosphere of the Brain-Based Learning class is relaxed because the incubation stage and memory entry done by listening to music and doing ice breaking. This causes students to feel enthusiastic and excited about learning.

3.2. Mathematical Creative Thinking on Treffinger Learning and PBL

From the Kolmogorov-Smirnov test, a significance value of the class that applied Treffinger Learning was Sig. = 0.170 > 0.05, so that Ho was accepted. It meant the data of mathematical creative thinking ability of the class that applied Treffinger learning came from a population that was normally distributed. Therefore, the z-test was used to test the classical completeness. The z-test for $\alpha = 5\%$, x = 28, n = 32, and $\pi_0 = 0{,}745$ gave the result the $z_{count} = 1{,}688$ and the $z_{table} = 1{,}64$. In this case, we infered that the students' mathematical creative thinking ability achieved classical completeness.

Refers to the Kolmogorov-Smirnov test result, the significance value of the class that applied Treffinger Learning and PBL was Sig. = 0.001 < 0.05, so that Ho was rejected. It meant the data of mathematical creative thinking ability of the class that applied Treffinger learning and PBLcame from a population that was not normally distributed. Therefore, the mean difference test used the Mann-Whitney test. The result of the Mann-Whitney test was Sig. = 0,00 < 0,005 so that Ho was rejected. It meant the mean of students' mathematical creative thinking ability in the class that applied Treffinger learning was more than that applied PBL. This result in line with [20], [21], [22] that students creative thinking skill of the class that applied Treffinger with RME principles was higher than that applied conventional model.

Mathematical creative thinking abilities allow it to be developed through Treffinger learning. In mathematics learning, the implementation of the Treffinger learning makes an improvement of mathematical creative thinking abilities. Students tend to show a positive response in Treffinger learning because each stage can stimulate students to think divergent. Presentation of material during the Treffinger learning process is carried out through discussion activities that aim to solve mathematical problems in order to develop students' creativity using affective and cognitive skills. In explaining learning material, the teacher actively engages students' thinking by providing open-ended problems and stimulating students to be able to find material concepts and principles independently. The teacher provides the opportunity for students to express diverse opinions or initial solutions related to the open problems presented. After that, students are faced with more complex problems and have a variety of steps and correct answers, giving rise to a tense situation that can spur students to unleash the potential for mathematical creative thinking. Students in class that applied the Treffinger learning model tend to be enthusiastic and feel challenged to come up with their creative ideas in solving open problems that are presented appropriately. Students can freely make observations and explorations with the aim of building their knowledge without sticking to the formula principles that are usually taught. Some of these positive responses affect mathematical creative thinking ability to develop more effectively. These results were in accordance with Nizam, *et al*. that the implementation of Treffinger learning increases student activity in asking questions and opinions, drawing conclusions, and produce illustrations of cases in daily life [23]. Trefffinger learning model improved students' creative thinking and problem-solving ability [24] and also mathematical abilities [25]. This study found students' mathematical creative thinking ability in the class that applied Treffinger learning was more than that applied PBL. Munahefi et al, found that PBL model with self-regulated learning (SRL) approach was effective to improve creative thinking ability. The SRL, indicated by among others self-confidence, motivation, goals, plays an important role in affecting student academic succsess [13] This shows that PBL needs to be modified in order to improve creative thinking ability.

3.3. Mathematical Creative Thinking on Brain-Based Learning and Treffinger Learning

The Kolmogorov-Smirnov test result, the significance value of the class that applied Brain-Based Learning and Treffinger Learning was Sig. = 0.002 < 0.05, so that Ho was rejected. It meant the data of mathematical creative thinking ability of the class that applied Brain-Based Learning and Treffinger Learning came from a population that was not normally distributed. Then, the mean difference test used the Mann-Whitney test. The Mann-Whitney test result was Sig. = 0,657 > 0,005 so that Ho was accepted. It meant the mean of students' mathematical creative thinking in the class that applied Brain-Based Learning was not more than that applied Treffinger learning.

In the class that implemented Brain-Based Learning and Treffinger Learning, both achieved classical completeness and there was no significant mean difference in mathematical creative thinking ability. Both of these lessons are fun for students so that students are enthusiastic and excited about learning. This positive response triggers the students' mathematical creative thinking abilities to improve more effectively. These were in accordance with Suarez, *et al* and Waree [8], [9].

4. Conclusion

The percentage of students in the class that applied the Treffinger learning achieved classical completeness and the mean of mathematical creative thinking ability of students in the class that applied the Treffinger learning was more than that applied Problem-Based Learning. The percentage of students in the Brain-Based Learning class achieved classical completeness and the mean of mathematical creative thinking ability of students that applied Brain-Based Learning was higher than that applied Problem-Based Learning. There was no mean difference in the students' mathematical creative thinking skills in the class that applied Brain-Based Learning and Treffinger learning. This research concludes that Brain-Based Learning and Treffinger learning were effective for developing students' mathematical creative thinking ability at junior high school.

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PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6