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The effectiveness of innovative learning model on the mathematical representation ability of students in junior high school

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Abstract. This study aims to analyze the effectiveness of the Learning Cycle 5E model in developing the mathematical representation ability of Junior High School Students. This study was quantitative. The population was students in Junior High School of grade VIII in Semarang. The sample was taken by a random sampling technique. The data were collected by a test. The data were analyzed by the z-test and t-test. The result showed that (1) students' mathematical representation ability on the Learning Cycle 5E class achieve classical completeness; (2) the average of mathematical representation ability on the Learning Cycle 5E class was higher than on the PBL class; and (3) the proportion of students' mathematical representation ability on the Learning Cycle 5E class was higher than on the PBL class. In other words, the Learning Cycle 5E model was effective in developing the mathematical representation ability of Junior High School Students.

1. Introduction

The ability to understand mathematics ideas more deeply, constructing conjecture, analogies and generalizations, logical thinking and mathematical communication and connections are classified in higher-order thinking skills. The components of higher-order thinking skills include problem-solving, reasoning, communication, mathematical connections, and representation. According to Shirley, the form of mathematical representation is divided into five, namely numerical, graphical, verbal, symbolic, and multiple representations. Graphical representation contains visual representation [1].

Topics in geometry related to other topics in mathematics, other fields, and daily life. Besides, visual, symbolic and verbal representation is needed to understand it. For students, visual representations are a bridge between symbolic and verbal representations [2]. Frege states the representations that can be used in mathematics is the symbolic writings of algebra [3], even numerical representations influence the strength of symbolic representations [4]. Geometric representations upgrade and give support for algebraic and arithmetic manipulation of the linear objects [5].

Mathematical representation is important for students to communicate ideas from the abstract to the concrete nature so that it is easier to understand. According to the National Council of Teacher Mathematics, students need five processes in learning mathematics, namely: (1) problem solving; (2) reasoning and proof; (3) communication; (4) connection; and (5) representations [6]. These skills are included in higher-order thinking or high-level thinking in mathematics



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learning. Since students of elementary school are still in the concrete operational stage, they require manipulable objects, the enactive and iconic representation to make connections with previously-acquired knowledge [7]. A problem that students consider very complex can be simpler if this representation ability is used in these problems. Incorrect construction of representation will make the problem more complicated and difficult to solve. The good mathematical representation will be able to simplify a complex problem into an easier problem. In the end, a solution can be found [8].

According to Bybee, one of the student-centered learning models and based on constructivist views is 5E Learning Cycle. There are 5 main stages in the 5E Learning Cycle, namely engagement, exploration, explanation, elaboration, and evaluation [9-10]. Furthermore, the 5E Learning Cycle is called an innovative learning model. The exploration and the elaboration stages can develop mathematical representation ability. These are because, in the exploration stage, students are allowed to investigate the environment in which one of the ways that can be done is by observing, asking questions, trying, or demonstrating. In conducting this investigation, students can take advantage of images of objects, such as images that can support students in understanding the lesson. With the elaboration stage, students use definitions, concepts, and skills they have in new situations. In using definitions, concepts, and skills, students no longer use the help of objects but can manipulate symbols directly.

Classroom learning activities must be structured to develop students' problem-solving skills [11]. Barrows and Hmelo-Silver state one of the student-centered pedagogical approaches that allow students (including prospective and certified teachers) opportunities to engage in goal-directed inquiry is Problem Based Learning (PBL). Students work together with others as they analyze difficult problems [12]. According to Arends, The PBL is a learning model in which students were deal with authentic (real) issues so that they have to be able to construct their learning, develop high-level skills and analysis, independent learners, and increase their courage. There are five phases on the PBL model namely orientation, organization, investigation, presentation, and evaluation [13].

The aim of this study is to analyze the mathematical representation ability, namely (1) The innovative learning model achieved classical completeness. (2) The average in the innovative learning model was higher than in the PBL model. (3) The proportion of students in the innovative learning model who have completed is higher than of students in the PBL. From now and on, we say the students' ability for the students' mathematical representation ability.

2. Method

This study was a quantitative, quasi-experimental, randomized posttest-only control design. The population was students in Junior High School of grade VIII in Semarang, Indonesia. The sample was taken randomly. A test of students' ability was conducted to gather the data. The data analysis used the z-test and t-test.

Classical completeness is achieved if at least 75% of students get the score ≥ 70 . To test the classical completeness, the z-test was used with the hypothesis as follows.

$H_0: \pi \leq 0,745$ (the classical completeness has not yet achieved)

$H_1: \pi > 0,745$ (the classical completeness has achieved)

The test criteria are by testing the proportions of the left with a significant level of 5% and H_0 is rejected if $z_{count} > z_{\frac{1-\alpha}{2}}$.

The following hypothesis was tested to know the average of students' ability.

$H_0: \mu_1 \leq \mu_2$ (the average of students' ability in the experimental class was not better than in the control class).

$H_1: \mu_1 > \mu_2$ (the average of students' ability in the experimental class was better than in the control class).

Since $\sigma_1 = \sigma_2$, then H_0 is accepted if $t_{count} < t_{table}$ where $t_{table} = t_{(1-\alpha)(df)}$ and H_0 is rejected if t_{count} has other values. The Degrees of freedom is $df = (n_1 + n_2 - 2)$.

A student is called completed if (s)he gets the score ≥ 70 of the test. The tested hypothesis to analyze the proportion of students in the experimental class who have completed was higher than of students in the PBL model was as follows.

$H_0: \pi_1 \leq \pi_2$ (the proportion of students in the experimental class who have completed was no better than of students in the control class)

$H_1: \pi_1 > \pi_2$ (the proportion of students in the experimental class who have completed was better than of students in the control class)

H_0 was rejected if $z_{count} > z_{0,5-\alpha}$ with a significant level of 5%.

The mathematical representation abilities, i.e students' abilities, in this study were visual, symbolic, and verbal. The aspects of representation measured in this study were making visual representations (pictures) to explain and facilitate problem-solving, formulating the given representations, determining solutions of problems using mathematical expressions, interpreting the representation, writing the steps in solving mathematical problems in words. The instrument to measure the mathematical representation ability was an essay test about the surface area and volume of cubes and right parallelepipeds. The example problem of the test was "Riri has a cube-shaped box with a side of 50 cm length. She wants to decorate the entire surface of the box with wrapping paper. In a store near Riri's house, gift paper is sold at Rp4,000 per square meter. Write down the steps to solve the problem. Determine the minimum cost that Riri spent to buy gift paper. If Riri has Rp30,000, how much is Riri's change?"

3. Result and Discussion

The Saphiro-Wilk test with the benefit of IBM SPSS Statistics 22 was used to test the normality of the data of students' ability in the experimental class. It was found that the data on students' abilities were normally distributed. The normality of students' ability of the control class using the Saphiro-Wilk supported by IBM SPSS Statistics 22, obtained data with a normal distribution. Test the combined data normality of the two classes using the Chi-Square test, obtained data derived from populations that were normally distributed.

The classical completeness test was used to determine whether the completeness percentage of students in the experimental class reaches at least 75% of the students in the class get a score of more than or equal to 70. From the calculation results $z_{count} = 1,949$ and obtained $z_{table} = 1,64$. The result was that $z_{count} > z_{table}$, so H_0 was rejected. It means the innovative learning model achieves classical completeness.

The average of students' ability was tested by the t-test. From calculation results $t_{count} = 1,88$ and for $\alpha = 5\%$, $n_1 = 30$, and $n_2 = 30$ it was obtained $t_{table} = 1,67$. The result was that $t_{count} > t_{table}$, so that H_0 was rejected. It was concluded that the average of students' ability in the innovative learning class was higher than the average in the PBL.

The proportion of students who have completed was tested by the z-test. From calculation results $z_{count} = 3,157$. For $z_{table} = 1,64$ then $z_{count} > z_{table}$ so that H_0 was rejected. Therefore, the proportion of students in the innovative learning model who have completed was higher than of students in the PBL model.

The result above followed the finding of Bilgin, Coşkun, & Aktaş that students in the innovative learning class learned terms in an essential and interconnected way. Moreover, the innovative learning model is useful in providing the relationship among concepts [14]. The finding of this study also in line with Tuna and Kaçar that found the innovative learning model affects the students' performance where students in the innovative learning model are found as more successful than those in the traditional model [15]. The stage of exploration supports students to understand lessons, while the elaboration stage supports students use the definitions, concepts, and skills they have in new

situations [9, 10]. In using definitions, concepts, and skills, students no longer use the help of objects but can manipulate symbols directly. These conditions lead students to reach better achievement.

4. Conclusion

The conclusions were (a) the students' ability in the innovative learning achieved classical completeness; (b) the average of students' ability in the innovative learning model was higher than of students in the PBL model; (c) the proportion of students in the innovative learning model who have completed was higher than of students in the PBL model.

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