The effect of creative problem solving on students’ mathematical adaptive reasoning

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Abstract. This research was conducted to analyse the effect of creative problem solving (CPS) learning model on the students’ mathematical adaptive reasoning. The method used in this study was a quasi-experimental with randomized post-test only control group design. Samples were taken as many as two classes by cluster random sampling technique consisting of experimental class (CPS) as many as 40 students and control class (conventional) as many as 40 students. Based on the result of hypothesis testing with the t-test at the significance level of 5%, it was obtained that significance level of 0.0000 is less than α = 0.05. This shows that the students’ mathematical adaptive reasoning skills who were taught by CPS model were higher than the students’ mathematical adaptive reasoning skills of those who were taught by conventional model. The result of this research showed that the most prominent aspect of adaptive reasoning that could be developed through a CPS was inductive intuitive. Two aspects of adaptive reasoning, which were inductive intuitive and deductive intuitive, were mostly balanced. The different between inductive intuitive and deductive intuitive aspect was not too big. CPS model can develop student mathematical adaptive reasoning skills. CPS model can facilitate development of mathematical adaptive reasoning skills thoroughly.

1. Introduction
The mathematical adaptive reasoning is a very important reasoning in learning. The mathematical adaptive reasoning is one of the mathematical skills that must be possessed by students to demonstrate their learning ability. This mathematical skill is not the innate skill of the students, but the combination of knowledge and the abilities and beliefs that students gain with the help of teachers and other learning environments. Hayat and Yusuf state that reasoning ability is one of the most important competencies required today and in the future in mathematics learning [1]. Kilpatrick, Swafford, and Findell argue that adaptive reasoning involves not only deductive reasoning that only concludes based on formal proofing deductively, but adaptive reasoning also includes intuition and inductive reasoning with conclusions based on patterns, analogies, and metaphors [2].

Adaptive reasoning has a wider scope than general reasoning that only includes inductive and deductive reasoning only, because in the process of adaptive reasoning also involves intuition. The adaptive reasoning is a necessary part to support success in the mathematics learning process. Adaptive reasoning needs to be continuously trained and developed so that math learning becomes more meaningful and achieves the expected learning objectives. Through adaptive reasoning, students are expected to be able to solve the problems quickly and precisely. Students will build their minds to master the concept of mathematics intact both for now, later and become the basis of students in acting logically in math activities, or in other daily activities.
Some aspects of adaptive reasoning are inductive and deductive reasoning associated with intuition. Inductive reasoning is a general conclusion based on observed data, whereas deductive reasoning is a conclusion based on agreed rules [3]. According to Copi, deductive reasoning is the process of inferences that are derived in absolute terms according to statements that are not influenced by other factors [4]. Intuitive knowledge is a kind of knowledge that is not based on sufficient empirical evidence or a strictly logical argument and although like that, it is nevertheless accepted with confidence and clearness [5]. While intuitive understanding occurs if someone can predict or suspect the truth of something without hesitation and without first analyzing analytically [6].

To train mathematical adaptive reasoning, students need to be given problems that facilitate them to develop the ability to adapt the situation given. Students are given non-routine problems that train their creativity in finding solutions. It's quite logical if they are guided by creative problem-solving learning. Problem-solving in mathematics mostly refers to Polya, which includes understanding the problem, devising a plan, carrying out the plan, and looking back [7]. Creative problem solving comes from the words creative, problem, and solving. Creative means many new and unique ideas in creating solutions and having value and relevancy, the problem means a situation that provides challenges, opportunities, interrelated, while solving means planning a way to answer from a problem [8].

Creative Problem Solving learning model is the development of problem-solving learning. Stages in this learning model represent systematic procedures in identifying challenges, creating ideas, and implementing innovative solutions. Through the practice and implementation of the process on an ongoing basis, students can strengthen their creative techniques and adaptive reasoning and learn to apply them in new situations. Creative techniques need an intuitive ability. This learning model is not like the problem-solving method in general, this model prefers to ideas given and then there is no immediate final decision or there is still a delay of the solution [9].

The role of teachers in learning that apply creative problem-solving learning model puts more of them as facilitator (to facilitate students in learning process), motivator (giving motivation to students in learning activities), and dynamicator (teacher try to give stimulation in searching, collecting, and determining information for troubleshooting) [10]. During the learning process using the CPS learning model, students are given wide opportunity to solve the given problems. It is a prerequisite for students who want to learn independently. The goal to be achieved is that students are directed actively in building their knowledge through direct experience so that the expected objectives of mathematics learning can be achieved well.

This research was conducted to analyze the effects of creative problem-solving learning model on the students' mathematical adaptive reasoning. The student's mathematical adaptive reasoning skills in this study are the ability to think logically about the relationship between concepts and situations through intuitive-inductive and intuitive-deductive reasoning. Intuitive capabilities and either inductive or deductive reasoning are not a sequence, so intuitive ability can be in any part of the inductive or deductive reasoning process. The Intuitive-inductive reasoning is the conclusion from the special to the general that involves the process of intuition. The Intuitive-deductive reasoning is the conclusion from a general to a specific involving the intuition process. The process of intuition is a process or activity for guessing, establishing something with or without the use of representational assistance but without first proving or explaining formally. However, in this study focused on two indicators namely, the ability to guess and make general conclusions based on the amount of data observed (inductive-intuitive) and the ability to guess and make logical conclusions (deductive-intuitive). The method used in this study was a quasi-experimental with randomized posttest-only control group design. Cluster random sampling technique consisting of experimental class (CPS) and control class (conventional).

2. Methods and material
The method used in this study was a quasi-experimental with randomized posttest-only control group design. Cluster random sampling technique consisting of experimental class (CPS) as many as 40 students and control class (conventional) as many as 40 students. In the experimental group given treatment in the form of learning by using Creative Problem-Solving learning model, while the control
group is given treatment by using conventional learning that is expository learning. After a certain period of time, both groups are observed, then given a posttest to know the difference of ability between the two groups. If there is a difference between the experimental group and the control group, it is can be concluded that the difference is due to the treatment was given. The design of experiment if R means random, X means treatment (CPS), and O means posttest, is as follows [11]:

| R | X | O |
|---|---|---|
| R | O |   |

Based on the explanation before, it can be formulated the learning with creative problem solving in this research, that is a model of problem-solving learning that emphasizes the discovery of various ideas or ideas that involve divergent and convergent thinking processes to find solutions in the form of the most efficient solution of a problem. Divergent thinking is generating ideas based on intuition in solving problems. Convergent thinking is a decision-making activity on the idea. The creative problem-solving stages used in this study were adapted from Mitchell and Kowalk [12], namely:

- **Fact-finding,**
  at this stage, students enroll all known facts related to the problem to be solved and look for other data required by involving divergent and convergent thinking processes.

- **Problem finding,**
  at this stage, the student identifies the problem statement and determines the important points underlying the problem by involving divergent and convergent thinking processes.

- **Idea finding,**
  at this stage, students are encouraged to develop a number of ideas that might be used to solve problems by involving divergent thinking processes.

- **Solution finding,**
  at this stage, students select the ideas acquired to find the most appropriate ideas in solving problems in a systematically way by involving divergent and convergent thinking processes.

- **Acceptance finding,**
  at this stage, students attempt to obtain the acceptance of problems solutions that have been found or to ensure successful solutions and to implement them by involving divergent and convergent thinking processes.

The instrument used in this research is a test to measure the students' mathematical adaptive reasoning, that is, the questions of 6 essays given in the form of posttest. This test instrument is given to the experimental class and control class on the rectangular and triangular subjects, where the tests given to the two classes are the same. The data needed in this research is the scores of students' mathematical adaptive reasoning in learning mathematics. Data collection is conducted by using the test technique, that is, the test of mathematical adaptive reasoning ability. The test is divided into two parts namely, a 10-minute for intuitive ability test and a 70-minute for reasoning ability test. Both parts of the test are conducted on the same day in each class. The test of mathematical adaptive reasoning is given to the experimental class, which in the learning process is given treatment with the CPS learning model, and control class is given conventional treatment that is by expository learning. The mathematical adaptive reasoning tests provided consist of six questions of the essay.

Instruments first tested before use so get a good instrument. This trial is intended to obtain the validity of items, the level of difficulty, the discriminant index, and the reliability of the instrument. The instrument was made of six questions about the ability of mathematical adaptive reasoning. After analyzing with statistical method, all items are valid. The level of difficulty analysis gives the result that the six items tested are at the medium level of difficulty. The analysis of Discriminant index gives the result that three of six items tested, between upper and lower class have the discriminant index in the medium category, two items are in a bad category and the others are in the good category. The reliability
analysis gives the results that the tried instrument has a sufficient of reliability coefficient of 0.573, which means that this instrument is enough to measure the ability of mathematical adaptive reasoning.

The collected data from both the control class and the experimental class were processed and analyzed to explain the problem under study. The overall of data processing from the normality test to the test of equality of two means was performed using SPSS software. The data analysis used was the test of two means equality with a technique of Independent Samples T-Test. The two-mean equality test is performed on the overall mathematical adaptive reasoning test results. Before testing the hypothesis first tested the normality and homogeneity as the assumed prerequisite for the t-test. After the analysis of prerequisite test was performed, the distribution of the average score of mathematical adaptive reasoning ability in the experimental class as well as the controls was the normal distribution and had homogeneous variance. Therefore, to test the equality of two means is used Independent-Samples T Test analysis.

3. Results and discussion
In particular, the students’ mathematical adaptive reasoning scores in both the experimental and control classes based on their indicators are presented in Table 1.

| Indicator         | Ideal Score | Experiment (CPS) | Control (Expository) |
|-------------------|-------------|------------------|----------------------|
|                   |             | Student Score | Percent | Student score | Percent |
| Intuitive-Inductive| 12          | 401         | 10.03   | 335          | 8.38   |
| Intuitive-Deductive| 12          | 375         | 9.38    | 325          | 8.13   |
| Overall           | 24          | 776         | 19.40   | 660          | 16.50  |

The percentage of mathematical adaptive reasoning scores obtained by the experimental class (CPS) is higher than the percentage of mathematical adaptive reasoning scores of control class for each indicator, both of intuitive-inductive or intuitive-deductive capabilities. The difference in intuitive-inductive capability in both classes is 13.75%, whereas in the intuitive-deductive ability it has a difference of 10.42% in both classes. The percentage of the overall score of mathematical adaptive reasoning of the experimental class is 12.08% higher than the control class.

Based on the result of hypothesis testing with the t-test at significance level of 5% as shown in Table 2, it was obtained that significance level of 0.0000 is less than α = 0.05.

| Table 2. The equality test of two means of mathematical adaptive reasoning |
|-------------------------|-----------------|-----------------|
| Levene’s Test for Equality of Variances | t-test for Equality of Means |
| F                      | Sig.            | T               | df | Sig. (2-tailed) |
| Equal variances        | 3.246           | .075            | 4.940 | .000           |

The result of homogeneity test using Levene’s test, at the significant level of α = 0.05 shows that the data of posttest score of mathematical adaptive reasoning ability of experiment class and control class is homogeneous, this is obtained by comparing the value of significance of calculation result with α which has been determined. The significance value listed on the homogeneity test results (sig. level = 0.075) is greater than the price of α = 0.05.

Testing of normality and homogeneity has shown that posttest scores of mathematical adaptive reasoning abilities in both groups are normally distributed and the variants of both groups are also equal or homogeneous, therefore testing of two means equality can be performed using the Independent Samples T-Test analysis. The result of the equality test of the two means of the experimental class and the control for the mathematical adaptive reasoning ability indicates to receive the alternative hypotheses and reject null hypotheses. The alternative hypotheses stated that the mean of students mathematical
adaptive reasoning ability whose learning using creative problem-solving learning model is higher than the mean of students mathematical adaptive reasoning ability using expository learning at 95% confidence level. It can be identified from the significance value (sig. level = 0.000) in Table 2 which less than the value of α = 0.05.

The results as in Table 2 show that the students’ mathematical adaptive reasoning skills who were taught by creative problem-solving model were higher than the students’ mathematical adaptive reasoning skills of those who were taught by conventional model. The result of this research showed that the most prominent aspect of adaptive reasoning that could be developed through a CPS was inductive intuitive. Two aspects of adaptive reasoning, which were inductive intuitive and deductive intuitive, were mostly balanced. The different between inductive intuitive and deductive intuitive aspect was not too big. CPS model can develop student mathematical adaptive reasoning skills. CPS model can facilitate the development of mathematical adaptive reasoning skills thoroughly.

The students' mathematical adaptive reasoning skills who applied to creative problem-solving learning models are higher than students’ mathematical adaptive reasoning skills who applied with conventional learning using expository model. This is in line with Pehkonen's opinion that creative thinking is a combination of divergent thinking based on intuition and logical thinking [13]. These creative aspects are needed in creative problem-solving learning model so that this model trains students to think divergently based on intuition and logical or convergent thinking. Divergent and convergent thinking based on intuition is both contained in students 'mathematical adaptive reasoning skills, so it can be concluded that creative problem-solving learning models can train and develop the students' mathematical adaptive reasoning skills.

The results of this study are also in line with the results of Desriyanti's research related to the influence of Thinking Aloud Pair Problem Solving (TAPPS) learning model to students' mathematical adaptive reasoning skills with an average value of 63.80, giving conclusion that TAPPS learning model is effective to improve student’s mathematical adaptive reasoning ability [14]. However, student’s mathematical adaptive reasoning skills applied by creative problem-solving model has higher mean value than student’s mathematical adaptive reasoning skills applied by TAPPS learning model that is 80.83, so it can be concluded that the creative problem-solving learning model is more effective to improve the students' mathematical adaptive reasoning skills.

The results of Mahmudah’s research about the influence of creative problem-solving model of the students’ critical thinking skills with the average of 59, gives the conclusion that the creative problem-solving learning model is effective to improve students' critical thinking skills [15]. However, when it compared with the students' adaptive mathematical reasoning skills that also applied the creative problem-solving learning model has a higher average value of 80.83. This shows the creative problem-solving learning model is effective for developing students' mathematical adaptive reasoning skills and critical thinking skills, but the creative problem-solving learning model is more effective for improving students' mathematical adaptive reasoning skills.

4. Conclusion
In The student’s mathematical adaptive reasoning skills whose applied creative problem-solving learning model has the best level of indicator on the ability to guess and make general conclusions based on the data observed (intuitive-inductive). However, the ability to guess and make logical conclusions (intuitive-deductive) is only slightly different with intuitive-inductive skills, even almost balanced. It can be said that the creative problem-solving learning model is an effective learning to develop students' mathematical adaptive reasoning skills on the aspects of intuitive-inductive and intuitive-deductive.

The students' mathematical adaptive reasoning skills who applied with conventional learning have the best level of indicator on the intuitive-inductive aspect rather than the intuitive-deductive aspect. In both aspects also have a difference that is not far away. Students who are learning with the conventional model have intuitive-deductive skills that are almost balanced with intuitive-inductive skills, despite the intuitive-inductive skills are greater. Overall, students taught with conventional learning models have mathematical adaptive reasoning skills that are balanced in both aspects, but low enough. It can be said
that the conventional learning model has not been effective enough to develop students' mathematical adaptive reasoning skills.

The students' mathematical adaptive reasoning skills who applied to creative problem-solving learning model is higher than the students' mathematical adaptive reasoning skills who applied to the conventional learning model. The students taught by creative problem solving have an edge both aspects of intuitive-inductive and intuitive-deductive then the students taught by conventional learning models. The differences in each indicator in both classes are very visible. Thus, creative problem-solving learning model is better than conventional learning model in developing students' mathematical adaptive reasoning skills.

Based on the conclusions obtained, the creative problem-solving learning model can be used to improve students' mathematical adaptive reasoning abilities, so it can be used as an alternative learning model that can be used by teachers in mathematics learning. This study was conducted at the junior high school level, therefore to get comparison of the results of the research conducted it is necessary to conduct further research for other subjects, other aspects of ability or school level different.

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