Effectiveness of the application of learning models collaborative problem solving against the ability to solve mathematical problems in middle school students

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Abstrak. The purpose of this study is to test the effectiveness of the application of collaborative problem-solving learning to students' problem-solving abilities. This research is a quasi-experimental study with a non-equivalent control group design. The sample used in this study consisted of 75 students consisting of 37 students in the experimental class and 38 students in the control class in one of Pekanbaru Riau Middle School, Indonesia. The instrument in this study was the student's initial ability test before being given treatment and tests after being given the Collaborative Problem Solving learning treatment. In this study found that learning Collaborative Problem Solving models are effective for improving the mathematical problem-solving abilities of junior high school students from students who receive conventional learning.

1. Introduction

Problem-solving skills are related to students' ability to read and understand the language of questions, present in mathematical models, plan calculations from mathematical models, and complete calculations from non-routine questions. Problem-solving skills must be improved in secondary school students because problem-solving skills are inherent in the secondary teaching and learning goals of mathematics [1]. Problem-solving skills can accompany students to act meticulously and critically in dealing with others and are able to connect knowledge, skills, understanding and reasoning power possessed by students in solving a problem.

Students in Indonesia are very minimal in mastering these mathematical problem-solving skills [2,3]. This statement is also in line with Sumarmo [4] The skills to solve problem-solving problems for high school students or junior high school students are still low. The same thing was also conveyed by Fitria [5] students 'mathematical problem-solving abilities were still low, students could not understand the problem and re-examine the problems given by the teacher. Overall the students' problem-solving abilities, especially in mathematical subjects are in low qualifications. Besides that, Krawec [6] mentions process skill errors that cause domain errors related to performance in problem-solving; for example, the visual–spatial domain is related to the creation of representations through visual schemes.

Based on the findings of the results of the study which explains that there is still a low mathematical problem-solving ability possessed by students so that an effort is needed in improving these abilities.
One effort that can be done is to apply an appropriate learning concept to improve the mathematical problem-solving abilities. One of the learning concepts that can be used in an effort to improve mathematical problem-solving skills is the Collaborative Problem Solving model. PISA [7] states that Collaborative Problem Solving (CPS) is an important and necessary skill used in education and in the world of work. Students gather their understanding and efforts and work together to solve problems. Collaboration has a distinct advantage over individual problem solving because it allows to: effective division of labor; incorporation of information from various perspectives, experiences, and sources of knowledge; increasing creativity and quality of solutions stimulated by the ideas of other group members.

The value contained in the Collaborative Problem Solving model is the positive communication between students in the group to raise the development of understanding, reasoning and critical thinking to unify the concepts of the diversity of opinions or thoughts issued by each individual to find the results of joint problem solving [8,9]. In groups, students are stressed to interact, ask each other questions and give opinions to improve their understanding. Interactions like this are ways to improve understanding, reasoning, critical thinking skills, problem-solving skills, and mathematical communication. Chasing the Collaborative Problem Solving model can lead students to be skilled in thinking logically and creatively about mathematical content through their involvement in Collaborative problem-solving tasks [10,11]. Aside from that, Kyungbin Kwon et al [12], the results of his research suggest that students who show solution-oriented behavior are more directing others to better solutions when collaborating. Conversely, students who have difficulty understanding problems show behavior that is more problem-oriented.

Thus, learning Collaborative Problem Solving models is thought to be effective for improving students' problem-solving abilities. The collaborative is defined by Roschelle and Teasley as synchronous and coordinated activities that are the result of continuous efforts to build and maintain a shared conception of a problem [7]. Collaborative Problem Solving according to Dillenbourg [13] is a collaboration carried out by two or more people who have the same goal, namely to solve a particular problem. This learning makes the collaboration process between students in solving problems is the main thing to be able to construct their own knowledge, armed with the initial knowledge of each student. Nelson [14] also argues that Collaborative Problem Solving is a combination of two learning approaches, namely cooperative learning and problem-based learning. Learning design is supported by student problem-solving activities where students can make agreements, based on the natural collaborative processes of each student.

Based on this opinion it can be concluded that the Collaborative Problem Solving learning model is a process of collaboration between two or more people who have the same goal to be able to make an agreement in a process trying to solve a problem. The agreement is based on each collaborative process with various understandings, combining knowledge and skills.

One of the objectives of learning mathematics is to solve problems that include the ability to understand problems, design mathematical models, solve mathematical models, and interpret solutions obtained. Polya argues [15], that problem solving is an activity or basic human activity. Problem-solving is a basic human activity that in theory and practice thinks with directed steps to find solutions to a problem [16,17] Then Ibrahim [18] explains mathematical problem solving is not a topic, but a fundamental process of the whole mathematical program that contextually helps concepts and skills to be learned. Szetela and Cynthia [19] add that problem solving when viewed from a mathematical angle is the process of dealing with new situations, fostering relationships between facts, knowing definite results or conclusions, and trying all possible strategies to achieve these results.

Based on the opinions of experts, it can be concluded that problem-solving is a basic and comprehensive process to overcome new situations by using the skills and knowledge that were previously owned and then followed by measurable steps to analyze and find solutions to the problem.

2. Methods
The type of research used is Quasi-Experiment with the design of Nonequivalent Control Group Design. With the research design as follows [20]:

| Group | Pretest | Perlakuan | Posttest |
|-------|---------|-----------|----------|
| Experiment | $O_1$ | X | $O_2$ |
| Control | $O_3$ | - | $O_4$ |

X : Treatment with Collaborative Problem Solving learning model

$O_1$ dan $O_3$ : Problem solving ability test before being given treatment.

$O_2$ dan $O_4$ : Problem solving ability test after being given treatment

In this study conducted in class VIII at Pekanbaru Middle School. The research sample was taken using a random class technique. The sample in this study consisted of 75 students with details of 37 students in the experimental group and the control group consisting of 38 students. The experimental class was treated by collaborative problem solving learning and the control class was given conventional learning treatment.

3. Result and Discussion

Descriptions of students' initial abilities before being given learning treatments from both groups are shown in the table 2.

| Aspects of Ability | Ideal score | Experimental Group | Control Group |
|--------------------|-------------|--------------------|---------------|
|                    | $X_{min}$ | $X_{max}$ | $\bar{X}$ | $S$ | $X_{min}$ | $X_{max}$ | $\bar{X}$ | $S$ |
| Problem-solving    | 20         | 2.00  | 7.00  | 3.027 | 1.236 | 1.00 | 7.000 | 3.158 | 1.386 |

Table 2 shows that the average pretest score of students in terms of mathematical problem solving for the experimental group and the control group is not much different, namely the average for the experimental group is 3.027 while the average for the control group is 3.158. While the data distribution is around the average in each group.

To find out whether the difference in pretest scores in the experimental group students and the control group was significant or not, the data were tested using the two average difference test, with the results as in table 3 below.

| Aspects of Ability | Experimental Group | Control Group | Sig. (2-tailed) | Ho acceptance |
|--------------------|-------------------|---------------|----------------|---------------|
|                    | $\bar{X}$ | $S$ | $N$ | $\bar{X}$ | $S$ | $N$ |
| Problem-solving    | 3.027 | 1.236 | 37  | 3.158 | 1.386 | 38  | 0.668 | Reject $H_0$ |

From table 3, the results of Asymp. Sig. (2-tailed) from the test of difference two mean the pretest score on solving ability is 0.668. If taken $\alpha = 0.05$ then the results of Asymp. Sig (2-tailed) 0.668 $> 0.05$ so that $H_0$ is accepted. So the conclusion is that the average value of the mathematical problem-solving ability in the experimental group and the control group did not differ significantly.
Information about students' abilities after the teaching and learning process in the experimental group and the control group was obtained from the posttest results. Table 4 below is descriptive which is obtained from the results of posttest score data processing of the experimental group and the control group.

| Aspects of Ability | Ideal score | Experimental Group | Control Group |
|--------------------|-------------|---------------------|---------------|
|                    |             | $X_{min}$ | $X_{max}$ | $\bar{X}$ | $S$ | $X_{min}$ | $X_{max}$ | $\bar{X}$ | $S$ |
| Problem-solving    | 20          | 9.00     | 19.00     | 13.46 | 2.77 | 1.00      | 17.00     | 11.97     | 2.02 |

From Table 4 it is known that the average score of mathematical problem-solving abilities of the experimental class students is 13.46 with a standard deviation of 2.71, while the average score for the control class is 11.97 and the standard deviation is 2.02. It was seen that the average value of problem-solving abilities from the experimental group was higher than the control group. The standard deviation value also shows that the data distribution in the two groups is not much different and is around the average.

To find out whether the difference in posttest scores in the experimental group students and the control group is quite significant or not, the data were tested using the two average difference test. With results like the following table 5.

| Aspects of Ability | Experimental Group | Control Group | Sig. (2-tailed) | Ho | acceptance |
|--------------------|---------------------|---------------|-----------------|----|------------|
|                    | $\bar{X}$ | $S$ | $N$ | $\bar{X}$ | $S$ | $N$ |               |    |            |
| Problem-solving    | 14.11 | 2.55 | 37 | 11.97 | 2.02 | 38 | 4.027 | Reject $H_0$ |

Table 5 show that the test of the difference in the two averages on mathematical problem-solving abilities shows that Asimp. sig. (2-tailed) 0.000 < 0.05, the hypothesis $H_0$ is rejected. Thus the average mathematical problem-solving abilities of students after the teaching and learning process in the experimental group and the control group differed significantly.

The average value of experimental group mathematical problem-solving ability $\bar{x}_{exp} = 14.11$ with an ideal score of 20 greater than the average value of the mathematical problem-solving ability of the control group $\bar{x}_{ctr} = 11.97$. This means that after the teaching and learning process is carried out, the mathematical problem-solving abilities of the experimental group students are those that use learning with collaborative problem-solving learning models better than the control or learning groups that use conventional learning. And from the standard deviation value, it can be concluded that the spread of data in each group is not much different and is around the average.

Information about improving students' mathematical problem-solving abilities after the teaching and learning process in the experimental group and the control group was obtained from normalized gain scores. Term normalization gain descriptive statistics included average gain, standard gain deviation, and index gain criteria. Complete data is shown in table 6.

| Table 6. Descriptive Statistics of Normalized Gain |
Table 6, it can be seen that the application of learning with the Collaborative Problem Solving model on mathematical problem-solving abilities resulted in a normalized gain score of 0.661 higher than the problem-solving ability with the application of conventional learning with a normalized gain score of 0.528.

In detail, increasing the ability of understanding and mathematical reasoning in the experimental class can be seen in Table 7.

### Table 7. Average Recapitulation of Normalized Gain Scores

| Item | Average Pretest Score | Average Posttest Score | Average Gain Score | Average N-Gain Score | Category |
|------|-----------------------|------------------------|--------------------|----------------------|----------|
| 1    | 1.081                 | 3.054                  | 1.973              | 0.676                | Medium   |
| 2    | 1.162                 | 2.622                  | 1.459              | 0.514                | Medium   |
| 3    | 1.189                 | 3.595                  | 3.405              | 0.893                | high     |
| 4    | 0.243                 | 2.135                  | 1.892              | 0.504                | Medium   |
| 5    | 0.351                 | 2.703                  | 2.351              | 0.644                | Medium   |

From Table 7, it can be seen that the magnitude of the increase in the average gain score of the five test questions increased mathematical problem-solving abilities provided there is one high and four medium categories, students' mathematical reasoning ability has a high category with an N-gain average of 0.893 is the question number 3 which relates to the ratio of the volume of the two prisms with the corresponding ribs.

To find out whether the difference in the normalized gain average score of the experimental class students and the control class is quite significant or not, the data are tested using the two average difference test.

The results of the calculation of the test of the difference between two averages for normalized gain score data mathematical problem-solving abilities of the experimental group and control group students are shown in the following Table 8.

### Table 8. Test Differences in Two Average Gain Scores Normalized Mathematical Problem Solving Ability of Experimental Group Students and Control Groups

| Aspects of Ability | Experimental Group | Control Group | Sig. (2-tailed) | Hypothesis |
|--------------------|---------------------|---------------|----------------|------------|
|                    | N                  | X̄             | S              | N          | X̄          | S          |               |            |
| Problem-solving    | 37                  | 0.661          | 0.137          | 38         | 0.528       | 0.094      | 0.000        | Reject $H_0$ |
solving learning models using conventional learning. The average normalized gain of mathematical problem solving in the experimental group $x_{\text{exp}} = 0.661$ is greater than the value of the average gain of mathematical problem solving in the control group $x_{\text{ctr}} = 0.528$, which means that after the teaching and learning process, improvement of problem solving skills Mathematically the experimental group students who use the problem solving collaborate learning model are better than the control group or learning group that uses conventional learning.

Student activities during the learning process with collaborative problem solving models as a whole show seriousness and high enthusiasm in accepting learning, especially in discussing and sharing arguments in solving problems, students are motivated to recall the material related to the problems to be solved, even though so there are still some students showing passivity in the discussion process.

After carrying out a post-test on mathematical problem-solving abilities in the experimental and control classes, researchers found several common mistakes made by students when solving problems. These mistakes generally make mistakes in identifying the elements and strategies that will be taken in solving problems so that they make conclusions about what is desired about the problem.

Based on the results of the test analysis of the average score difference of data about mathematical problem-solving abilities of students showed that the average mathematical problem-solving abilities of students using Collaborative Problem-Solving learning models were higher than the average students who did not use the Collaborative Problem Solving learning model. Likewise, the results of the analysis of the difference in the average N-Gain score test showed that there were significant differences between the experimental group students and the control group. In the sense that there is an increase in the achievement of problem-solving abilities of students who receive learning in the Collaborative Problem Solving model of students who do not use the Collaborative Problem Solving learning model.

4. Conclusion

Based on the results of data analysis on students' mathematical problem-solving abilities in learning Collaborative Problem Solving models and with conventional learning, it can be concluded that there is an increase in mathematical problem-solving abilities of students who have learned Collaborative Problem-Solving models showing better results than students who obtain conventional learning. This means that learning Collaborative Problem Solving models is effective for improving students' mathematical problem-solving abilities.

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