Student mathematical communication capability improvement using the metacognitive strategy

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Abstract. This study aims to determine the improvement of students' mathematical communication skills using metacognitive strategies. The method used was quasi-experimental with a non-randomized control group post-test control group design. The sample of this study was the junior high school students of class VIIA and VIIB as experimental and control classes with many students in each class 19 and 17 people. The instrument used was a test of mathematical communication skills. The results showed that students' mathematical communication skills using metacognitive strategies were better than students who used conventional learning. Thus the metacognitive strategy can be used as an alternative strategy to improve students' mathematical communication skills.

1. Introduction
Mathematics is a unique field of science, besides having strong and clear structure and study between concepts. The uniqueness of this field of science also lies in the mathematical object itself in the form of facts, concepts, symbols, operations that are abstract, and only present in the human mind. By learning mathematics, students are expected to reason and think logically, analytically, critically, creatively and can work together [2]. This is in accordance with the general objectives of mathematics learning formulated by the National Council of Teacher of Mathematics: (1) learning to communicate (mathematical communication); (2) learning to reason (mathematical reasoning); (3) learning to solve problems (mathematical problem solving); (4) learning to associate ideas (mathematical connections); (5) the formation of positive attitudes towards mathematics (positive attitudes toward mathematics [9].

Related to the first goal of mathematics learning by NCTM above, mathematical communication is the central force for students in formulating mathematical concepts and strategies; as a capital of students' success in approach and resolution in mathematical exploration and investigation; and communication as a forum for students to obtain information or share thoughts, assess and sharpen ideas to convince others [10].

Mathematical communication is very important because we need communication in learning mathematics if we want to achieve full social goals such as lifelong learning and mathematics for everyone. If mathematics is considered a language and communication tool, communication is an important factor in teaching, learning and accessing mathematics. Without communication in
mathematics, only a little information, data, and facts about students' understanding that we get or we know in a learning process in class [8].

Even though communication skills are important, they are not yet fully achieved by students. This can be seen from several indicators, including Bergeson's research results which state that students find it difficult to communicate visual information especially in communicating a three-dimensional environment (for example, a building made of small blocks) through two-dimensional tools (for example, paper and pencil) or vice versa. Likewise the results obtained by Indonesian students at the TIMSS event in 2007 showed that Indonesian students were still weak in terms of mathematical communication, as happened with students' answers to one of the questions about reading data in a pie chart and presenting it in the form of bar charts. Only 14% of Indonesian participants were able to answer correctly, while at the international level there were 27% of students who answered correctly [11].

Based on the facts above, learning needs to be made that can improve communication skills in mathematics learning. Therefore, school mathematics learning programs must provide opportunities for students to: (1). Arrange and link their mathematical thinking through communication. (2). Communicate their mathematical thinking logically and clearly to their friends, teachers, and others. (3). Analyze and assess the mathematical thinking and strategies used by others. (4). Use the language of mathematics to express mathematical ideas correctly [9].

One learning strategy that is considered to improve mathematical communication skills is the Metacognitive Strategy. The metacognitive strategy, in this case, uses small groups consisting of four to five people with heterogeneous abilities. Furthermore, this learning is called Cooperative Learning with the Metacognitive Strategy (PK-SM). Cooperative learning is learning that adheres to the constructivism paradigm, namely the learning process asking for instruction design that relates to students as builders rather than recipients of knowledge, students who build their own knowledge through interaction and relate their previous experiences and knowledge to the current situation, and those who have learning strategies to build knowledge and understanding of the concepts they learn together in their study groups [6].

Metacognitive strategies are monitoring one's cognition to achieve certain goals, for example when students ask themselves questions about work and then observe how well they answer the questions [4]. Metacognitive strategies are also decisions made by students before, during, and after the learning process and are techniques used in planning, monitoring and controlling, and evaluating their own cognitive processes [1, 6].

Metacognitive strategies are chosen by researchers to be applied in mathematics learning because they have been successfully used by previous researchers, among others, that metacognitive strategies can succeed in bringing students to solve mathematical problems and can improve students' efficiency in open problem solving [13]. The reasoning and critical thinking abilities of students using metacognitive training are superior to other cooperative groups, [12]. Metacognitive strategies can improve problem-solving skills [14]. Furthermore, cooperative learning is recommended because it can develop and improve students' mathematical understanding [6,7].

2. Method
The research design was in the form of a pretest-posttest control group design with two classes, namely a class that used Cooperative Learning with a Metacognitive Strategy (PK-SM) as an experimental class and a class that used the conventional approach as a control class. Each class has 19 and 17 people and is a class VII student in the 2018/2019 academic year in one of the junior high schools in Bekasi. PK-SM has six stages of activity with each stage involving metacognitive questions. The stages of cooperative learning in question are 1) Delivering goals and preparing students (present goals and sets); 2) Present information; 3) Organizing students in study groups (organize students in to learning teams); 4) Helping group work and learning (Assist teamwork and study); 5) Group presentations; 6) Provide provide recognition [3].

The test used to measure mathematical communication skills consists of 5 items in the form of descriptions. To find out the increase in the ability of students' mathematical generalization before and after learning activities, the analysis was carried out as follows:
Normalized Gain (g) = \frac{postscore - pretesscore}{idealscore - pretesscore} [5].

Tabel 1. Level of Normalized Gain Score

<table>
<thead>
<tr>
<th>The amount of gain (g)</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.7 ≤ g ≤ 1</td>
<td>High</td>
</tr>
<tr>
<td>0.3 ≤ g &lt; 0.7</td>
<td>Medium</td>
</tr>
<tr>
<td>0 ≤ g &lt; 0.3</td>
<td>Low</td>
</tr>
</tbody>
</table>

3. Results and Discussion

The results of data analysis on the pretest value of the experimental group and the control group showed that the initial ability of students in the two classes was different, namely the larger control group (50.71) compared to the experimental group (29.79). After being given treatment, the results of the data analysis showed that the average posttest value of the experimental group was higher compared to the control group. The experimental group reached 66.37 while the mean value in the control group only reached 58.88. The mean N-gain value indicates that in the experimental group is 0.53 while the control group is 0.2. The mean N-gain of the experimental group is in the moderate category, while the average N-Gain value of the control group is in the low category (Table 1).

Table 2. Students' pre-test, post-test, and N-gain statistics experiment and control group

<table>
<thead>
<tr>
<th>Description</th>
<th>Experimental Group</th>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-test</td>
<td>Post-test</td>
</tr>
<tr>
<td>Mean</td>
<td>29.79</td>
<td>66.37</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>23.44</td>
<td>15.20</td>
</tr>
<tr>
<td>Mean of N-gain</td>
<td>0.53</td>
<td>0.20</td>
</tr>
<tr>
<td>Standard deviation of N-gain</td>
<td>0.14</td>
<td>0.08</td>
</tr>
</tbody>
</table>

Based on the results of inferential statistical tests (t-test) the results of t values are 9.605 with a probability (sig.) of 0.000 (less than 0.05) so H0 is rejected, in other words, the alternative hypothesis (H1) is accepted which means there is a difference in capacity enhancement mathematical communication between students taught using PK-SM with conventional learning (Table 3).

Table 3. t-Test results two free samples

<table>
<thead>
<tr>
<th>T</th>
<th>Df</th>
<th>Sig.(2-tailed)</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.605</td>
<td>34</td>
<td>0.000</td>
<td>Reject H0</td>
</tr>
</tbody>
</table>

The above results indicate that Cooperative Learning with Metacognitive Strategy (PK-SM), clearly affects the learning outcomes (mathematical communication skills) of students. This indicates that cooperative learning is learning that adheres to the constructivism paradigm, namely the learning process asking for instruction design that relates to students as builders rather than recipients of knowledge, students who build their own knowledge through interaction and connect their previous experiences and knowledge with the current situation, and they also who have learning strategies to build knowledge and understanding of the concepts they learn together in their learning groups [6].

The influence of PK-SM can also be seen in the average initial ability of students (before treatment), the control group has the initial ability tends to be greater (50.71) than the experimental group (29.79), but after being treated the experimental group outperformed the group control. This is due to the fact that in the experimental group there was thoughtful monitoring by students in the learning process that made students always aware and correct their shortcomings both before, while and after the learning process occurred by always asking themselves. This is also because the
metacognitive strategy is monitoring one's cognition to achieve certain goals, for example when students ask themselves questions about work and then observe how well they answer the questions [4].

The findings of this study are also reinforced by some of the results of previous studies that metacognitive strategies can improve students' mathematical problem-solving skills and can improve students' efficiency in solving open problems [14, 13].

4. Conclusion

Based on the results and discussion of the above research, several things can be concluded, as follows.

(1) Improvement (mean N-Gain) of students' mathematical communication skills using cooperative learning with metacognitive strategies (experimental group) are in the moderate category, while those in conventional learning (control groups) are in the low category. (2) There are differences in mathematical communication skills between groups of students who use cooperative learning with metacognitive learning strategies with groups of students who use conventional learning.

5. Reference


