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Problem-based learning model to improve mathematical communication skills and self-efficacy

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Abstract

This study aims to determine the improvement of mathematical communication skills and mathematical self-efficacy of grade VII students of SMP Negeri 1 Bantul by implementing the problem based learning model. The research model used in this classroom action research is the Kemmis and McTaggart model, which consists of four stages: planning, acting, observing, and reflecting. The data were collected through observation sheets on the implementation of learning, tests of mathematical communication skills, and self-efficacy questionnaires. Data analysis techniques through descriptive quantitative and qualitative techniques. The results showed that the implementation of the problem based learning model can improve mathematical communication skills and self-efficacy. The improvement can be seen from the test results which show that 25% of students have minimum high mathematical communication skills in pre-action, increased to 81.25% in cycle II and 56.2% of students had a minimum high self-efficacy in pre-action, increased to 78.125% in cycle II.

Keywords: mathematical communication skill, problem based learning, self-efficacy

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INTRODUCTION

These Mathematical communication skills are one of the process standards in mathematics learning that must be developed (NCTM, 2000). According to Hutapea (2019), mathematical communication is not just writing down mathematical ideas to solve problems but also how students communicate, explain, and describe mathematical ideas. In this study, there were four indicators of mathematical communication skills (Saputra, 2021) that were measured, namely (1) presenting mathematical statements in pictures, tables, graphs, diagrams, and algebraically; (2) stating contextual problems in mathematics language (using terms, mathematical symbols); (3) perform mathematical manipulations; and (4) draw conclusions, gather evidence, provide reasons or evidence of the correctness of the solution. In general, the mathematical communication skills of students in Indonesia are still relatively low. It can be seen from the results of PISA 2018 released by the OECD (2019) that Indonesia is ranked 73 out of 79 countries with an average score of 379, far below the international average of 489 in the field of mathematics. PISA is an international survey that tests mathematical literacy problems that focus on the ability of students to analyze, reason, and communicate mathematical ideas effectively to solve various mathematical problems.

In addition, based on the results of preliminary research and interviews, it was found that students of SMP Negeri 1 Bantul, especially class VII C, had difficulty in presenting mathematical statements in graphs and diagrams wholly and precisely. In contrast, only six out of 30 students could present graphs/diagrams wholly and precisely. Only four out of 30 students could correctly state daily events in mathematical language, and the average score of students performing mathematical manipulation was 4.7 out of 10. Also, in concluding, collecting evidence, and providing reasons or evidence of the correctness of solutions, the average score of learners was

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3.6 out of a total score of 9. The four aspects tested are indicators of mathematical communication skills, where overall, there are just six students in the high category, ten in the excellent category, and 13 in the low category. So, the preliminary research concluded that the mathematical communication skills of class VII C students of SMP Negeri 1 Bantul need to be improved.

According to Saputra and Zulmaulida (2020), one factor that affects students' low mathematical communication skills is low self-efficacy because low self-efficacy will provide a slump in the students themselves so that they are reluctant to hone their mathematical communication skills. This self-efficacy is one of the affective abilities that are very important for students to have. The self-efficacy aspect determines how a person feels, thinks, motivates, and acts. Self-efficacy in mathematics is self-confidence in presenting and solving mathematical problems, learning or working on understanding concepts and completing tasks, and communicating mathematics with friends or teachers during learning (Ramadhani & Siregar, 2021). The self-efficacy indicators measured in this study are 4 points, namely (1) confidence in the skills to understand mathematical material; (2) confidence in the skills to complete mathematics-related tasks; (3) the belief in successfully achieving goals in mathematics learning; and (4) confidence in resilience and tenacity in mathematics learning (Fitriani & Pujiastuti, 2021).

Apart from international survey data and some studies, students lack mathematical communication skills in the last three years of the national test or called UN junior high school results. UN is one of the government's efforts to evaluate the results of the implementation of the national education process in Indonesia before it was abolished in 2020 and replaced by The National Assessment, which is currently still in the trial stage. The data shows that geometry and measurement materials are stagnant in the 40s, which is always lower than other materials on average. It shows that, indeed, the ability of students in this geometry material is still lacking. So, it can be concluded that the mathematical skills in geometry materials in grade 7, especially in the quadrilaterals and triangles chapters, need to be improved.

One of the efforts to develop mathematical communication and self-efficacy of students on quadrilaterals and triangles material is the preparation of appropriate learning tools. Mathematics learning tools and selecting more mature learning models prepared and focused on mathematical communication and self-efficacy will be an effective effort. Educators should make this learning plan according to the aspects to be developed. It is following the Minister of Education and Culture Number 22 of 2016 concerning the standards of the primary and secondary education process, where teachers must have professional competencies to develop a lesson plan to suit the needs of students (MOEC, 2016). Nevertheless, unfortunately, the devices used in schools have not been able to facilitate the development of mathematical communication skills and self-efficacy of students. It can be seen from the results of preliminary research conducted by researchers, which showed that both aspects are still low. In addition, this is confirmed by the teacher who teaches the class, the teaching materials used for the learning process so far are student worksheets which are sold in general, not special devices that are adapted to the conditions of students. On the other hand, the research of Rafli, Syahputra & Yusnadi (2018) and Hadi and Izzah (2018), shows that learning with the Problem based learning model can develop mathematical communication skills. Also, following the research of Amir et al. (2018), Problem based learning can increase students' self-efficacy.

Based on the description above, class action research is needed to implement problem based learning models to improve mathematical communication skills and self-efficacy of class VII students of SMP Negeri 1 Bantul for quadrilaterals and triangles material.

RESEARCH METHOD

This type of research is Classroom Action Research. The research model used in this classroom action research is the Kemmis and McTaggart model, which consists of four stages: planning,

acting, observation, and reflection (Kemmis, McTanggart, & Nixon, 2014). The subjects in this study were students of class VII C of SMP Negeri 1 Bantul, the 2021/2022 academic year, which amounted to 32 students.

This research was conducted on a cycle and each cycle consists of four stages: planning, acting, observation, and reflection. The planning stage starts by finding problems in the field by observing the learning process and conducting interviews at SMP Negeri 1 Bantul, especially class VII C, then designing the actions to be carried out. The implementation of actions in this study will be carried out in two cycles. Observation and Evaluation are used as the basis for reflection and planning improvements in the following action. This reflection process is carried out to analyze the data that has been obtained and evaluate the previous process that has been carried out. The cycle would be stopped if it has reached the criteria of success, otherwise, it would be continued.

The success criteria of this research are more than 70% of students have minimum mathematical communication skills and self-efficacy in the high category. Research instruments through observation sheets on the implementation of learning, mathematical communication skills tests, and self-efficacy questionnaires. The mathematical communication skills and self-efficacy results are calculated from the number of scores from each respondent and then added up, analyzed, and categorized using formulas. The determination of the categorization of students' mathematical communication and self-efficacy is carried out by dividing them into five categories according to the opinion of Widyoko (2016) as presented in Table 1.

Table 1. Categorization of students' mathematical communication and self-efficacy

Mathematical Communication Skills		Self-efficacy	
Score Interval	Categorize	Score Interval	Categorize
$\bar{x} > 80$	Very High	$\bar{x} > 102$	Very High
$60 < \bar{x} \leq 80$	High	$84 < \bar{x} \leq 102$	High
$40 < \bar{x} \leq 60$	Moderate	$66 < \bar{x} \leq 84$	Moderate
$20 < \bar{x} \leq 40$	Low	$48 < \bar{x} \leq 66$	Low
$\bar{x} \leq 20$	Very Low	$\bar{x} \leq 48$	Very Low

RESULTS AND DISCUSSION

The researcher does a pre-action that consists of a mathematical communication test and a self-efficacy questionnaire as initial data for conducting this study. The following Table 2 is the pre-action results of students' mathematical communication skills and self-efficacy.

Table 2. Pre-action result of students' mathematical communication and self-efficacy

Mathematical Communication Skills		Self-efficacy	
Categorize	Percentage of frequency	Categorize	Percentage of frequency
Very High	0%	Very High	15,625%
High	25%	High	40,625%
Moderate	34,375%	Moderate	37,5%
Low	34,375%	Low	6,25%
Very Low	6,25%	Very Low	0%

From the data above, it is obtained that students' mathematical communication skills still need to be improved. It can be seen from the table above that none of the students reached the very high category; 25% in the high category, 34.375% in the moderate category, 34.375% low category, and 6.25% in the very low category. As for self-efficacy, the pre-action results show that

15.625% of students have a very high level of self-efficacy, 40.625% in the high category, 37.5% in moderate category, and 6.3% in low category. Although 56.25% of students' self-efficacy is in minimum high category, the self-efficacy of students still needs to be improved to achieve the success criteria that the researcher has determined.

In the learning implementation of cycle I, the teacher used the problem based learning model and it has gone well. The percentage of the implementation in cycle I have reached 100%. Based on observations, the results of reflections with students, and discussions with mathematics teachers, there are several advantages and disadvantages during the learning process in cycle I. The pre-action and cycle I result show that students' mathematical communication skills and self-efficacy have improved in cycle I. Although it has increased, it has not yet reached the success criteria in this study; namely, more than 70% of students have minimum mathematical communication skills and self-efficacy in the high category based on test results. To determine the effect of the implementation of the problem-based learning model, researchers compared the data with the results of students' mathematical communication skills and self-efficacy in pre-action in the following Figure 1.

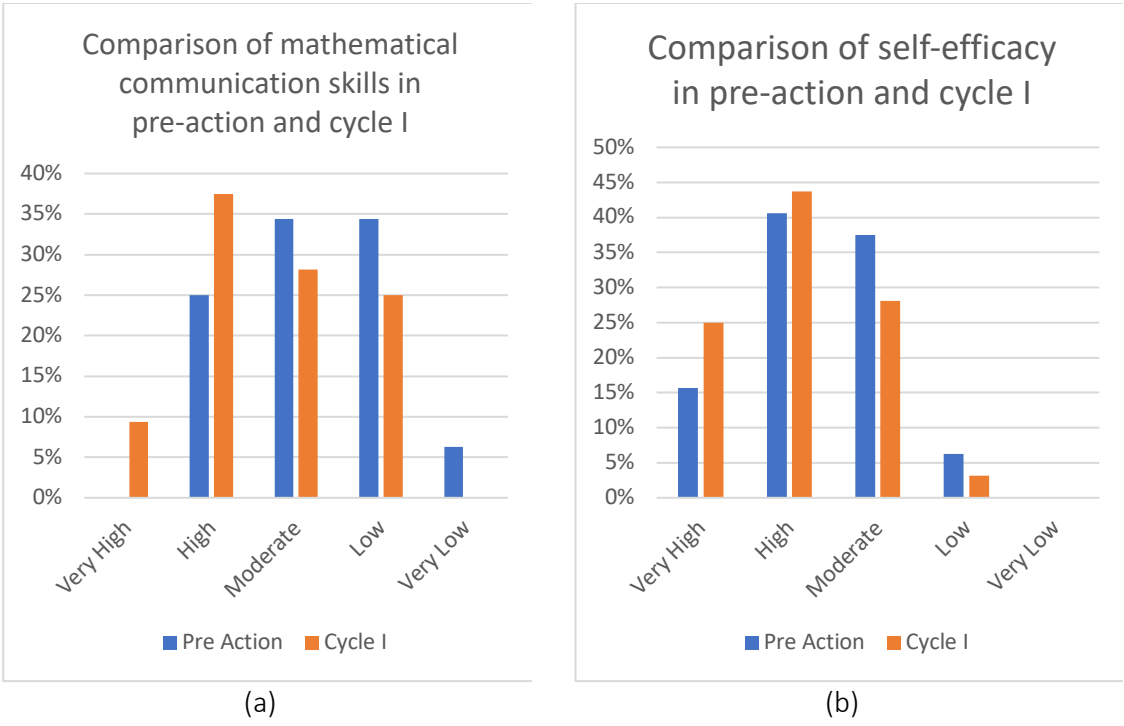

Figure 1. Comparison of mathematics communication skills in pre-action and cycle I (a), and comparison of self-efficacy in pre-action and cycle I (b).

From the diagram above, it can be seen that there is an improvement in students' mathematical communication skills and self-efficacy from pre-action to cycle I. The improvement can be seen from the test results which show that 25% of students have minimum high mathematical communication skills in pre-action, increased to 46.875% in cycle I and 56.2% of students had a minimum high self-efficacy in pre-action, increased to 68.75% in cycle I. Because cycle I has not been successful, it is necessary to continue cycle II research to achieve the success criteria that the researcher has targeted.

The planning process in cycle II is based on reflection on cycle I. Next, the researcher draws up a plan of improvement to be carried out for cycle II. Based on the reflection on cycle I, in blended learning, we need to dive groups by combining students who learn online and to make

it easier for students to understand, especially the student who learn online with the help of their peers who learn offline. In the learning implementation of cycle II, the teacher still used the problem based learning model and it has gone well. The percentage of the implementation in cycle II has reached 100%. Based on observations, no serious problems were found because the implementation of cycle II improved cycle I. To determine the success of the implementation of the problem-based learning model, researchers compared the results of students' mathematical communication skills and self-efficacy in cycle II with the result in cycle I in the following Figure 2.

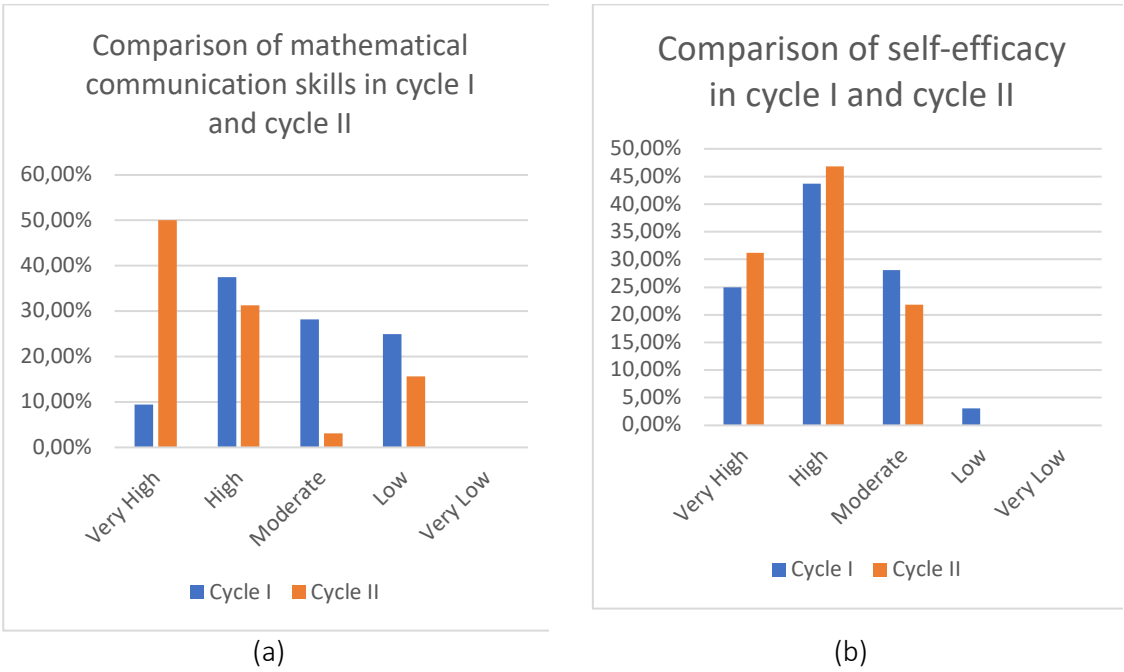

Figure 2. Comparison of mathematics communication skills in cycle I and cycle II (a), and comparison of self-efficacy in cycle I and cycle II (b).

From the diagram above, it can be seen that there is an improvement in students' mathematical communication skills and self-efficacy from cycle I to cycle II. The student's mathematical communication skills test results have reached the criteria for success in this study, with 81.25% of students having a minimum high mathematical communication skills. Also, the results of students' self-efficacy questionnaire have reached the criteria of success in this study, with 78.125% having a minimum of high self-efficacy. It shows that the implementation of problem-based learning can improve students' mathematical communication skills and self-efficacy.

The implementation of the problem based learning model to improve the mathematical communication skills and self-efficacy of students is carried out following learning steps according to Rusman (2014), namely 1) orienting students to problems; 2) organizing learners to learn; 3) guiding individual/group examinations; 4) develop and present the work; and 5) analyze &evaluate the problem-solving process. Based on the implementation of actions, the problem based learning model seems to hone students' mathematical communication skills and self-efficacy if prepared properly.

The first step in problem based learning is to orient students to the problem. In its implementation, students' curiosity arises because the problems that researchers provide are exciting and close to daily life, so students' self-efficacy increases along with their belief that the material is easy and exciting. The selection of problems carried out by researchers also pays attention to indicators of mathematical communication skills. In this case, the researcher always

provides contextual problems in the “lets see the problem” section for the students’ worksheets at every meeting.

Then in the second step, organize learners to learn. In implementing this second step, the teacher has an essential role in conditioning the class in such a way that the class is conducive to discussion and solving existing problems. The group division is a group division that follows the learning objectives, paying attention to students' activeness or gender. A good group division is expected to make students actively discuss to solve problems to improve mathematical communication skills as well as self-efficacy of students. Based on the implementation of blended learning, dividing groups by combining students who learn online and offline is more effective and makes it easier for students to understand with the help of their peers.

The step of guiding the examination of individuals or groups here means that the researcher assists the learner in the investigation or in completing the “Exploration” section of students’ worksheets that researcher compiled. This step is the core step of problem based learning, where students will get generalizations from the results of their investigations, so teachers need to continue to guide their students. The assistance or guidance this researcher provides is undoubtedly in the form of questions that can help students. Researchers do not give answers directly regarding learners' difficulties because the best help for learners is a question that can make learners reason and find solutions to the problem so that their self-efficacy can increase.

Developing and presenting the work is the next step in a problem based learning model. In this step, students are asked to explain the solution to the problem. The mathematical communication skills of students here will be required to develop both written and oral communication skills because before presenting the results of the work, of course, they write down what will be conveyed in sequence. In the implementation, making presentations and getting reinforcement from teachers can make students more confident in their abilities.

The last step of this problem based learning model is to analyze and evaluate the problem-solving process. In this step, researchers facilitate students with “Back to the problem” activities at students’ worksheets in every meeting. After studying and obtaining reinforcement during presentations related to learning concepts and materials, students have good self-efficacy in solving these problems. The problems given are specific problems that meet the indicators of mathematical communication skills.

Apart from being seen from the observation of the implementation of the learning process, the implementation of problem based learning to improve students' communication skills and self-efficacy is also proven from the test results and student questionnaires in each cycle. Students' mathematical communication skills and self-efficacy continue to increase in each cycle and achieve research success criteria in cycle II with 81.25% of students having minimally high mathematical communication skills and 78.125% having a minimum high self-efficacy. The results of this study follow the results of previous studies, namely the research of Rafli, Syahputra & Yusnadi (2018) and Hadi and Izzah (2018), that learning with the PBL model can develop mathematical communication skills. In addition, following the research of Amir et al. (2018), Problem based learning can increase students' self-efficacy. Based on the results obtained from cycle I and cycle II, it can be concluded that implementing the problem based learning model can improve mathematical communication skills and self-efficacy of class VII students of SMP Negeri 1 Bantul.

CONCLUSION

Based on the results of research and discussion, it can be concluded that 1) the application of the problem based learning model can improve mathematical communication skills and self-efficacy of students' VII class SMP Negeri 1 Bantul, 2) the improvement of students' mathematical communication skills can be seen from the test results which show that 25% of students have

minimum high mathematical communication skills in pre-action, then to 81.25% of students have mathematical communication skills minimum high in cycle II, 3) improvement in students' self-efficacy can be seen from the results of the questionnaire which showed that 56.2% of students had a minimum high self-efficacy in pre-action, to 78.125% of students had a minimum high self-efficacy in cycle II.

The recommendations given in this study are, 1) for teachers, the results of this study can be used as a solution to improve the mathematical communication skills and self-efficacy of students if the material to be delivered can be applied to a problem based learning model, and 2) for subsequent researchers, the results of this study can be used as comparison material and reference for research. Furthermore, researchers are expected to be able to explore other factors that affect mathematical communication ability or self-efficacy.

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