International Journal of Multicultural and Multireligious Understanding

http://ijmmu.com
editor@ijmmu.com
ISSN 2364-5369
Volume 12, Issue 8
August, 2025
Pages: 584-593

Efforts to Improve Students' Mathematical Communication Skills with Problem Based Learning (PBL) Model at SMPN 3 Yogyakarta

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http://dx.doi.org/10.18415/ijmmu.v12i8.6916

Abstract

This study examines the improvement of students' mathematical communication skills through the application of the problem-based learning (PBL) model. The research is a Classroom Action Research conducted at SMP Negeri 3 Yogyakarta and involves 32 students of class VIII as research subjects. Data were collected through mathematical communication ability tests, which were analyzed quantitatively. The research consisted of two cycles. The results showed a significant improvement in students' mathematical communication skills, as evidenced by the increase in the average score from 59.74 in the diagnostic test, to 68.58 in cycle I, and reaching 83.33 in cycle II. The improvement was also reflected in students' learning completeness: the percentage of students who achieved the Learning Objective Completeness Criteria (KKTP) was only 25% (8 out of 32 students) in the diagnostic test and cycle I, but rose to 75% (24 out of 32 students) in cycle II. Thus, it can be concluded that the problem-based learning (PBL) model is effective in improving students' mathematical communication skills.

Keywords: *Classroom Action Research; Problem Based Learning; Mathematical Communication*

Introduction

Learning is a process of change in the form of knowledge, behavior, traits, and attitudes as a result of certain experiences that take place over time which allows a person to improve performance skills (Ambrose, Bridges, DiPietro, Lovett, & Norman, 2010). Learning can also be interpreted as a systematically structured process involving learning components including teaching materials, teachers, students, and learning environments that interact with each other so as to achieve goals (Dick, Carey, & Carey, 2015).

Mathematics is a subject that can improve thinking and reasoning skills, contribute to problem solving in everyday life and in the world of work, and support the development of science and technology. Mathematics is still very much needed today and in the future, because it will be very influential in life. This means that it is necessary for someone to learn mathematics.

Mathematics learning is a process of interaction between teachers and students in an organized form of activity to obtain information, be able to understand, and have the ability to communicate back the information obtained previously. The interaction or reciprocal relationship between teachers and students is the main way for the continuity of the mathematics learning process.

Based on the Ministry of Education and Culture website (2024), the objectives of mathematics learning include equipping students to; 1) have mathematical understanding and procedural skills, 2) be able to reason and mathematical proof, 3) solve problems, 4) communicate and mathematical representation, 5) mathematical connections, and 6) mathematical disposition.

From the explanation above, it can be seen that one of the abilities in learning mathematics, namely mathematical communication skills, has an important role. Based on the results of interviews with VIII grade subject teachers at SMPN 3 Yogyakarta, it shows that most students still have difficulty in re-presenting mathematical.

In addition, students also have difficulty in working on problems that they consider uncommon and have not been able to visualize mathematical models.

This is reinforced by the results of an initial diagnostic test conducted to measure mathematical communication skills in 32 students of grade VIII of SMPN 3 Yogyakarta. This test used mathematical ability indicators set by NCTM (2000). The test results are presented in table 1 below:

Table 1 Diagnostic test results of mathematical communication skills

Category	Total	Indicator I	Indicator II	Indicator III
Number of Students Completed (≥ score 75)	8	12	10	15
Percentage of Student Completion (in %)	25	37,5	31,25	46,89
Average Score	59,74	58,60	59,21	61,41

Table 1 shows that only 8 out of a total of 32 students (25%) VIII SMPN 3 Yogyakarta were declared complete, while the class average was only 59.74 which is still far from the KKTP value set by SMPN 3 Yogyakarta which is 75.

Based on the description above, it can be concluded that innovation is needed in the form of an effective learning model to help students improve their mathematical communication skills. One learning model considered appropriate is the problem-based learning (PBL) model. The PBL model is one of the two approaches recommended in the implementation of the 2013 curriculum as well as the independent curriculum. This is because PBL is a student-centered model that presents contextual problems, enabling students to explore their knowledge through group discussions. In addition, PBL fosters students' curiosity and enthusiasm for learning (Rahman, 2017).

Therefore, in this study, the researchers applied the problem-based learning (PBL) model as an effort to improve the mathematical communication skills of grade VIII students at SMPN 3 Yogyakarta.

Theoretical Overview

Mathematical Communication Ability

In general, communication refers to the process of transmitting information, ideas, or messages from one entity to another. This process inherently involves components such as sender, message, channel, and receiver, often complemented by a feedback mechanism (Littlejohn & Foss, 2011). Communication can manifest in various modalities, both verbal (spoken and written) and non- verbal (e.g., gestures and facial expressions).

In line with this, Sumarmo (2013) suggests that mathematical communication skills include several important aspects, namely: the ability to represent situations, images, diagrams, or other real-world contexts in the form of language, symbols, ideas, and mathematical presentation models; the ability to explain and read mathematical ideas meaningfully; the ability present, understand, interpret, and evaluate mathematical ideas.

Sumarmo (2013) suggested several key indicators that can be used to measure students' mathematical communication skills. These indicators include: 1) Connecting Representations: Students' ability to relate concrete objects, image visualizations, and diagrams to mathematical concepts or ideas. 2) Expressing and Explaining Mathematical Ideas: Students are able to explain ideas, situations, and connect mathematical problems orally and in writing, using real objects around, pictures, diagrams, or algebraic forms. 3) Representing Everyday Events: Students' ability to restate everyday events using mathematical symbols. 4) Participating in Discussions: Students can listen, discuss, and formulate mathematical questions. 5) Constructing Arguments: Students' ability to make assumptions and construct coherent mathematical arguments.

In addition, NCTM (2000) suggests that students' mathematical communication skills are reflected through several indicators, namely: (1) ability to express mathematical ideas: students are able to present mathematical ideas orally and in writing (2) ability to understand and evaluate mathematical ideas: students can understand, interpret, and evaluate mathematical ideas conveyed either orally, in writing, or visually. (3) ability to use mathematical concepts and notations: students are able to utilize mathematical concepts, notations, and structures to represent and describe ideas through situation models.

In this study, the indicators of mathematical communication skills used are indicators from NCTM (2000), with the following description:

1) Ability to express mathematical ideas: students are able to present mathematical ideas orally and in writing (as indicator I)
2) Ability to understand and evaluate mathematical ideas: students are able to understand, interpret, and evaluate mathematical ideas conveyed either orally, in writing, or visually. (as indicator II)
3) Ability to use mathematical concepts and notations: students are able to utilize mathematical concepts, notations, and structures to represent and describe ideas through situation models. (as indicator III).

Problem Based Learning Model

The problem-based learning (PBL) model is a problem-based learning model by assigning real-world problems to students through small group discussions to be understood and solved so that students understand and master relevant concepts and solution procedures (Johnson & Johnson, 2019). This problem-based learning or PBL model makes real-world problems a stimulus for the learning process before students understand formal concepts with students working in groups to explore, interpret, synthesize information from problems, and solve the problems given, while the teacher presents the problem, conducts questions and answers, and provides guidance during the problem investigation process (Rozana, Makmuri, & Hakim, 2020).

Poblem-based learning (PBL) is one of the learning models that is highly recommended in the Merdeka Curriculum. The emphasis of t h e Merdeka Curriculum on student-centered learning, critical thinking, and problem solving skills is in line with the characteristics of PBL. Through PBL, students are encouraged to actively construct their knowledge by solving real-world problems, which in turn develops important skills such as collaboration, communication, and creativity (Kemendikbudristek, 2022). Therefore, PBL is considered as an effective approach to achieve the learning objectives proclaimed

In Merdeka Curriculum, preparing students for the challenges of the 21st century. Rahman (2017) states that the problem-based learning model is a learning model that presents contextual problems that can arouse enthusiasm, attract or stimulate students to learn.

The characteristics of this problem-based learning model are: (1) The teacher as a facilitator to explore and find solutions; (2) Learning is done in small groups; (3) Learning is centered on students; (4) Problems in everyday life given to students become a stimulus and focus of learning to find principles or concepts in certain materials and develop students' problem-solving skills so that information is obtained after carrying out independent learning (Buyung, Sumarli, & Rosmaiyadi, 2020).

The application of the problem-based learning model consists of five steps or syntax, namely: orienting students to the problem; organizing students to learn; conducting investigations independently and or in groups; developing and presenting results; analyzing and evaluating results (Arends, 2012).

Research Methods

Place and Time of Research

This research was conducted from October 28 to November 07, 2024iin the odd semesteriof the 2024/2025 academic year.

Subjects and Objects of Research

The subjects in this study were VIII grade students of SMPN 3 Yogyakarta, totaling 32 students. While the object in this research is the mathematical communication skills of students by using a problem-based learning model (PBL).

Research Instruments

This research uses test instruments, namely cycle tests to measure the level of change achieved by students in mathematical communication skills. achieved by students in mathematical communication skills. All instruments have gone through an expert validation process by one of the mathematics teachers at SMPN 3 Yogyakarta.

Research Design

This research is a Classroom Action Research. Classroom action research is research conducted by teachers as researchers in order to improve and enhance the learning process and student learning outcomes (Anggraeni & Nurani, 2018; Annury, 2019; Aqib & Chotibuddin, 2018). Classroom action research involves teachers as researchers to identify problems, design actions, implement actions, observe, and reflect on the results, then plan the next cycle based on the reflection. Classroom action research is generally carried out in the form of continuous cycles. Each cycle consists of four main stages, namely: planning, acting, observing, and reflecting.

Classroom action research is conducted by examining problems within a limited scope, through self-reflection activities. This situation is related to the teaching practice of a teacher in a particular situation and location, where the teacher examines for himself how far the impact of the treatment he has planned beforehand on the process and learning outcomes of his students. This assessment is carried out to change, improve, and improve the quality of teaching and learning that occurs in the classroom. (Farhana, Awiria, & Muttaqien, 2019).

Research Procedures

This study followed the standard procedure of classroom action research, which includes four stages: planning, implementation, observation, and reflection. The research design adopted a multi-cycle approach, where each cycle consisted of two meeting sessions. At the end of each cycle, an evaluation was conducted through tests to measure progress in students' mathematical communication skills. The research process was concluded when a significant improvement in students' mathematical communication skills was achieved. This improvement was determined based on the percentage of mathematical communication skill test scores that exceeded the KKTP threshold of 75, in accordance with the standards set by SMPN 3 Yogyakarta.

Results and Discussion

Results

a) Cycle I

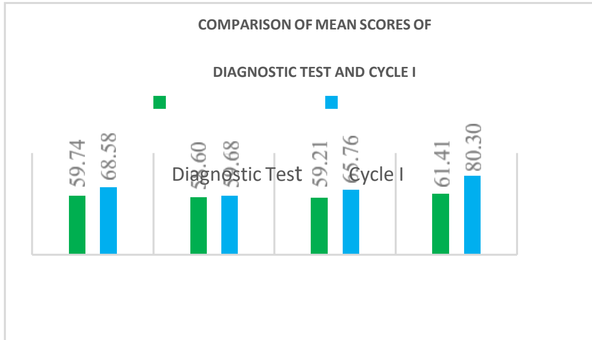
The learning process in cycle I was carried out in class VIII of SMPN 3 Yogyakarta, adopting a scientific approach to study the basic concepts and properties of the Pythagorean theorem. In this phase, the researcher played an active role as a learning facilitator. The treatment in cycle I focused on arousing students' curiosity through the presentation of contextual problems. Furthermore, students were directed to discuss in groups using the Learner Worksheet (LKPD). The hope is that this approach will encourage students to find their own learning concepts to be learned, thus making the learning process more meaningful.

As described, this learning activity involves group discussions that are formed randomly. Each group received guidance from the teacher to overcome obstacles during the discussion process. Cycle I evaluation was conducted at the end of the learning period. The evaluation was in the form of an individual test designed to measure students' mathematical communication skills on the basic concepts and properties of the Pythagorean theorem. This test was followed by the VIII grade students of SMPN 3 Yogyakarta, totaling 32 students. Table 2 describes the results of the first cycle test.

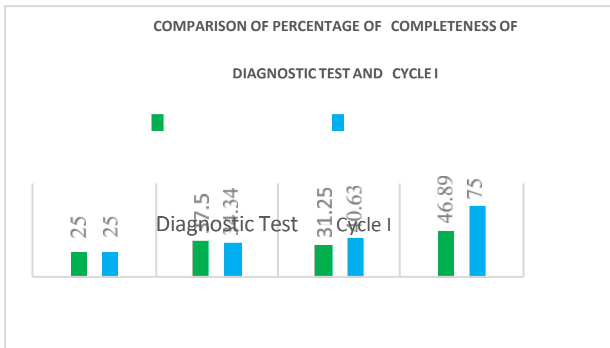
Table 2 Mathematical communication ability test results cycle I

Category	Total	Indicator I	Indicator II	Indicator III
Number of students Completed (≥ score 75)	8	11	12	24
Percentage of Student Completio n (in %)	25	34,34	40,63	75
Average Score	68,58	59,68	65,76	80,30

Based on Table 2, observations showed no significant change in the total number of students who achieved mastery between the diagnostic test and Cycle I, with eight students who were declared complete (total score of ≥ 75) in both phases. Nonetheless, there was an increase in the average score and completeness per indicator. Further details of this improvement will be presented in graph 1 and graph 2.



Graph 1 Comparison of Average Values of Diagnostic Test and Cycle I



Graph 2 Comparison of Percentage of Completion of Diagnostic Test and Cycle I

Based on data analysis, although there was an increase in scores between the pre and post-treatment phases, the overall achievement of students was still relatively low and had not met the KKTP of ≥ 75. Specifically, only the third indicator, namely students' ability to use mathematical terms, notations, and structures to present ideas, showed an average score and percentage of passing above 75%. Given that student learning outcomes have not yet reached the KKTP target, this research will continue to Cycle II.

b) Cycle II

Lesson planning in Cycle II is a follow-up to the results of Cycle I reflection. As previously identified, one of the factors causing students' low mathematical communication skills is that there are many students who during the learning process only focus on memorizing formulas and examples of problems from the teacher in class, which results in students not being able to analyze if given different types of problems. In addition, the heterogeneity of students' initial abilities is also a significant obstacle when students are forced to receive uniform learning treatment (Darkasyi, Johar, & Ahmad, 2014).

Given the results of the previous reflection, Cycle II implemented a change in learning approach to Teaching at the Right Level (TaRL). In addition, the teaching tools were also revised to support this new approach. TaRL emphasizes scaffolding learners according to their level of learning readiness. Scaffolding is assistance to students at the beginning of learning, then assistance will be reduced after students can work on their own (Slavin, 2014).

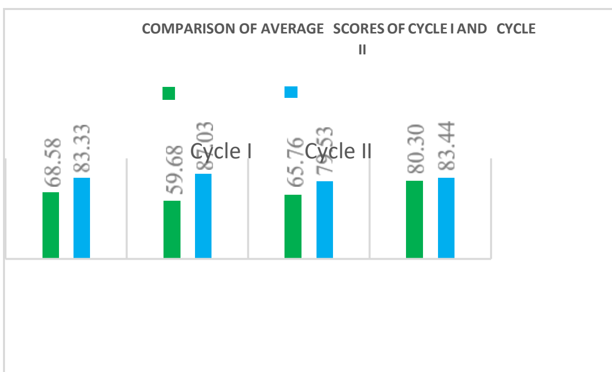
In this cycle II learning process, the student grouping strategy is designed heterogeneously based on the initial ability that has been assessed by the teacher. Each group was formed with a composition of students who had high, medium and low abilities in a relatively balanced proportion. The purpose of this group design is to facilitate peer tutoring during group discussions, which is expected to improve students' overall understanding and learning outcomes. Indrianie (2015) says that peer tutoring is a learning process where high-achieving students help underachieving students to overcome their lag. In other words, this method allows students who have a good understanding of the material to become tutors for peers who need help.

Evaluation was conducted at the end of cycle II. The evaluation was carried out by giving a test of students' mathematical communication skills on the Pythagorean theorem material. This test was attended by 32 students of class VIII who were done individually. Table 3 describes the results of the cycle II test:

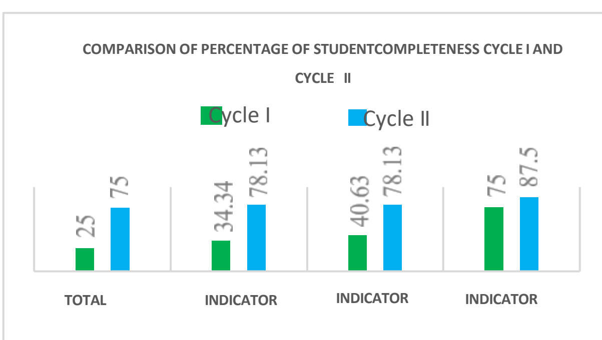
Table 3 Mathematical communication ability test results cycle II

Category	Total	Category I	Category II	Category III
Number of students Completed (≥ score 75)	24	25	25	28
Percentage of Student Completio n (in %)	75	78,13	78,13	87,5
Average Score	83,33	87,03	79,53	83,44

Based on the data presented in Table 3, it can be seen that the overall average score and per indicator have exceeded the KKTP score of 75. In addition, the percentage of student completeness also reached more than 75%. Further comparison of the increase in average scores between Cycle I and Cycle II can be observed in graph 3 and graph 4.



Graph 3 Comparison of Average Values of Cycle I and Cycle II



Graph 4 Comparison of Percentage of Student Completion Cycle I and Cycle II

Data analysis showed a significant increase in student scores after Cycle II treatment. ≥The average overall score obtained reached 83.33, which has exceeded the KKTP of 75. In addition, the percentage of student completeness also showed an increase, reaching 75%. If measured per indicator, the average value of the three indicators is more than KKTP, where indicator I (presentation of mathematical ideas through oral and written) has an average value of 87.03 with 78.13% completeness; indicator II (namely the interpretation of mathematical ideas through the ability understand, convey, and evaluate mathematical ideas by oral, written and visual means) has an average value of 79.53 with a percentage of student completeness of 78.13%; and indicator III (namely the application of formal mathematical language through the use of mathematical terms, notation and structures to present mathematical ideas) had an average score of 83.44 with a percentage of student completeness of 87.5%. Considering that the Given that the student learning outcomes obtained had reached the KKTP (≥ 75), this research was stopped in cycle II.

Discussion

Based on the test results, the average value of mathematical communication skills of class VIII students showed a significant increase after the implementation of the Problem-based learning (PBL) learning model. Before the treatment, the average score was 59.74. This figure then increased to 68.58 in Cycle I, and reached 83.33 in Cycle II. This data indicates that the PBL learning model is effective in improving students' mathematical communication skills.

A significant increase in students' learning completeness was observed, with the number of completed students increasing from 8 to 24 out of 32 students at the end of Cycle II. This data indicates that the PBL learning model contributed to the substantial improvement of students' mathematical communication skills. This statement is in line with the views of Rahman (2017) who argued that the problem-based learning (PBL) model is effective in presenting contextual problems. This approach is able to arouse enthusiasm and stimulate students' learning motivation, where they actively build their own knowledge and understanding through group discussions followed by class discussions.

Discussion activities in this lesson, supported by the Teaching at the Right Level (TaRL) approach, allow students to learn according to their ability level. This reduces the gap between students' prior knowledge and the material to be learned, thus facilitating active interaction, expression of opinions, asking questions, responding to peers' ideas, and the ability to re-explain thinking in solving problems.

Conclusion

The A Classroom Action Research study conducted in **Class VIII at SMPN 3 Yogyakarta** revealed that implementing the **Problem-based learning (PBL) model** significantly **improved students' mathematical communication skills.**

Prior to the intervention, the students' average mathematical communication score was **59.74**, with a mere **25%** completion rate. Following Cycle I, the average score rose to **68.58**; however, the student completion percentage remained at **25%.** As this average score was still below the **Learning Objectives** Completeness Criteria **(KKTP)** of 75 and the student completion rate had not reached 75%, the research proceeded to Cycle II. In Cycle II, a substantial improvement was observed: the average mathematical communication ability score increased to **83.33**, and the completion percentage reached **75%**. This means that **24 out of 32 students** achieved learning completeness, and the overall class average score surpassed the KKTP. These findings suggest that PBL is a **successful approach** for enhancing students' mathematical communication skills within the scope of this study.

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