



The Effect of Read, Outline, Discussion, Evaluation (RODE) and Problem-Based Learning (PBL) Models on Students' Mathematical Communication Skills

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Article Info	Abstract
Article history: Received: January 8, 2026 Accepted: March 23, 2026 Published: May 24, 2026	This study aims to compare the effectiveness of the RODE and PBL learning models in improving students' mathematical communication skills. The study employed a quasi-experimental nonequivalent-group pretest-posttest design involving two experimental groups. The research sample consisted of 44 eighth-grade students of MTs Al-Imam Asy-Syafi'i in Tarakan, North Kalimantan, Indonesia. The students were divided into two groups: Experimental group 1 was taught using the RODE model, and experimental group 2 was taught using the PBL model. Data were collected through pretests and posttests in the form of three essay questions measuring the indicators of written text, drawing, and mathematical expression. The normality test indicated that the N-Gain data were not normally distributed; therefore, inferential analysis was conducted using the Mann–Whitney U test. The results showed that the mean N-Gain of the RODE group (0.8290) was higher than that of the PBL group (0.6107). The Mann–Whitney U test showed a significant difference between the two groups ($U = 157.50$, $Z = -2.07$, $p = 0.038$), with the mean rank of the RODE group (26.34) higher than that of the PBL group (18.66). Thus, there was a significant difference in the improvement of students' mathematical communication skills between the two learning models. These findings indicate that the RODE model is more effective than the PBL model in improving students' mathematical communication skills, particularly on the topic of linear equations in one variable at MTs Al-Imam Asy-Syafi'i in Tarakan, North Kalimantan, Indonesia.
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INTRODUCTION

Education functions as a primary foundation for developing competent and competitive human resources. Through formal schooling, learners are encouraged to cultivate cognitive abilities, attitudes, and responsible behaviors that respond to contemporary societal challenges (Hidayatulloh & Sumartini, 2022; Sa'adah & Sumartini, 2021; Syah & Sofyan, 2021). According to Article 1(20) of Indonesian Law No. 20 of 2003 on the National Education System, learning refers to the interaction among students, educators, and learning resources within a learning environment. Among school subjects, mathematics plays a central role because it contributes to the development of analytical and higher-order thinking skills.

As a core discipline within the school curriculum, mathematics contributes substantially to the development of students' logical reasoning, analytical thinking, and systematic problem-solving abilities. For this reason, it is mandated as a required subject across all

stages of formal schooling, beginning at the primary level and continuing through secondary education (Linda & Afriansyah, 2022). Mathematics is often described as both the “queen of sciences” and the “servant of sciences” because it underpins and supports advancements in various other domains of knowledge (Fadilah & Afriansyah, 2021; Istiqomah & Nurulhaq, 2021; Yusriyah & Noordiyana, 2021). Achieving proficiency in mathematics extends beyond performing calculations accurately; it also involves the capacity to express and interpret mathematical reasoning effectively through spoken explanations and structured written representations (Widiyanto & Yunianta, 2021).

The capacity to communicate mathematically enables learners to grasp concepts more meaningfully, justify their reasoning, and translate their understanding into various forms of representation such as symbolic expressions, visual illustrations, graphical displays, and formal models (Hakiki & Sundayana, 2022; Madhavia, Murni & Saragih, 2020; Melinda & Zainil, 2020). Within the learning process, communication in mathematics extends beyond internal cognitive activity; it also functions as a medium for collaborative exchange in the classroom, facilitating dialogue between instructors and learners (Hanisah & Noordiyana, 2022). This competence encompasses the precise use of mathematical terminology and the ability to critically examine and respond to the reasoning presented by peers (Aljura et al., 2025). When expressed in written form, mathematical communication requires structured organization of arguments, explicit connections among concepts, and clear justification of solutions (Aladwan et al., 2023). Learners who demonstrate strong communication competence typically present solution strategies in a logical sequence and exhibit more comprehensive conceptual insight.

Despite the growing emphasis on mathematical competence, national and international assessment results indicate that Indonesian students still face substantial challenges in effectively communicating mathematical ideas. Data from PISA 2022 indicate that a relatively small proportion of Indonesian participants reached the minimum proficiency benchmark in mathematical literacy, with achievement levels far below the OECD average (OECD, 2023). A similar pattern appears in the TIMSS findings, where Indonesia’s mean performance score was recorded at 386, placing the country 38th among 58 participating nations, which reflects weaknesses in interpretation and representational skills (Layliyyah, Wisudaningsih & Rahayu, 2022). Consistent with these large-scale assessments, Andini & Marlina (2021) found that many students struggled to relate visual representations to underlying mathematical concepts and to clearly justify their solutions. Additional evidence also indicates that learners frequently encounter obstacles when attempting to solve problems and articulate their reasoning in mathematical form (Amelia et al., 2025).

Preliminary observations conducted in Grade VII of MTs Al-Imam Asy-Syafi’i in Tarakan, North Kalimantan, Indonesia, during the 2024/2025 academic year indicated similar conditions. The average student test score was 63.9 on a 100-point scale, which was below the school’s minimum mastery criterion, with 64% of students failing to achieve mastery. Students experienced difficulties in explaining solution steps, constructing visual representations such as tables or graphs, and actively expressing their ideas during discussions. This condition is presumed to be influenced by teacher-centered instructional practices, in which students tend to passively receive information without sufficient opportunities to ask questions, discuss, or articulate their reasoning (Mirna et al., 2023; Putri & Sundayana, 2021).

To overcome these challenges, it is necessary to implement an instructional model that actively engages students in the learning process. One instructional model frequently applied for this purpose is Problem-Based Learning (PBL), a student-centered model that emphasizes solving contextual problems and encourages students to collaborate while expressing mathematical ideas (Hafidloh et al., 2020; Madhavia et al., 2020). PBL is

characterized by contextual problem orientation, active student participation, collaborative investigation, and the development of higher-order thinking skills (Ardianti et al., 2021; Pohan & Rambe, 2022). Its syntax generally consists of five phases: orienting students to the problem, organizing students for learning, guiding individual and group investigation, developing and presenting the results of the work, and evaluating the problem-solving process (Pohan & Rambe, 2022; Yulianti & Gunawan, 2019). In many educational contexts worldwide, PBL has been applied in mathematics classrooms, especially at the primary and secondary levels, because it stimulates inquiry, cooperative work, and higher-order thinking. Studies have reported that this model has been implemented across various mathematical topics, including algebra, geometry, and arithmetic, and has been associated with improvements in problem-solving performance, student motivation, teamwork, systematic reasoning, and communication skills (Ayari et al., 2025). In addition, Ndia et al. (2025) found that learners exposed to PBL achieved better outcomes in mathematical communication than those who experienced direct instruction. Nevertheless, several studies have noted that unequal participation during group activities may limit the development of communication competence among some students (Wijaya & Yusup, 2023). These findings indicate the need to adopt a model that offers clearer structural guidance to support the development of students' mathematical communication.

Another instructional model relevant to this purpose is RODE, an acronym for Read, Outline, Discussion, and Evaluation. RODE is a structured instructional model designed to promote students' active participation and communication skills through systematic learning stages (Kusuma et al., 2022b, 2024). The model is characterized by student-centered learning, collaborative activities, and explicit guidance in organizing and communicating ideas (Kusuma et al., 2022b, 2023). Its syntax consists of four stages: Read, in which students identify and understand information or problems; Outline, in which they organize ideas and formulate possible solutions; Discussion, in which they present, discuss, and respond to ideas collaboratively; and Evaluation, in which they reflect on and assess both the learning process and outcomes (Kusuma et al., 2022b). Empirical studies by Kusuma et al. (2022a, 2022b, 2023, 2024) have shown that the implementation of RODE contributes positively to students' communication skills, encourages them to present their ideas more clearly and systematically, and supports deeper conceptual understanding through reflective evaluation activities.

Despite the extensive body of literature on problem-based learning in different educational settings, investigations focusing on the RODE approach are still relatively limited. At the junior secondary level, especially in learning materials related to linear equations in one variable, empirical applications of both approaches have not been widely explored. In addition, comparative studies examining how PBL and RODE influence students' mathematical communication skills remain scarce. Therefore, this study aims to compare the effectiveness of PBL and RODE in improving students' mathematical communication skills.

METHODS

The present study employed a quasi-experimental nonequivalent-group pretest-posttest design involving two experimental groups (Gribbons & Herman, 1997). The participating classes had been established prior to the study; therefore, random assignment of students was not possible. Both groups were administered a pretest before the instructional intervention and a posttest after the intervention to measure changes in students' mathematical communication skills. The overall research framework is summarized in Table 1.

Table 1 Non-equivalent-group pretest-posttest design

Group	Pretest	Treatment	Posttest
Experimental 1	O_1	X_1	O_2
Experimental 2	O_3	X_2	O_4

Description:

- $O_{1,3}$: Pretest for Experimental Group 1 and Experimental Group 2
 X_1 : Instruction using the RODE learning model
 X_2 : Instruction using the PBL learning model
 $O_{2,4}$: Posttest for Experimental group 1 and Experimental group 2

The participants of this study were all Grade VIII students of MTs Al-Imam Asy-Syafi'i in Tarakan, North Kalimantan, Indonesia, during the 2025/2026 academic year, with a total of 44 learners. Because the number of classes was limited to two, the entire population was included through a saturated sampling technique. Class VIII-A was assigned to the first experimental group and was taught through the RODE approach, whereas Class VIII-B functioned as the second experimental group and was instructed through the PBL approach.

Data were collected using written assessments administered before and after the instructional treatment, each containing three open-ended questions. The indicators of mathematical communication skills used in this study were adapted and synthesized from Suparni et al. (2021), Nashihah (2020), and Maulyda (2020). Based on these references, the indicators were classified into three dimensions: written text, drawing, and mathematical expression. A detailed description of these dimensions is provided in Table 2.

Table 2 Indicators of mathematical communication skills

No	Indicator	Description
1	Written text	the ability to explain ideas or solution steps in written form
2	Drawing	the ability to create visual representations of a given problem
3	Mathematical expression	the ability to express a problem in a mathematical model

Prior to implementation, the instrument underwent validity and reliability analysis using a significance level of 5%. The findings indicated that all items met the required criteria for both validity and reliability, confirming their suitability for data collection. Detailed outcomes of these analyses are summarized in Tables 3 and 4.

Table 3 Validity and reliability results of the pretest instrument

Item Number	Calculated r	Table r	Category	Reliability (α)	Description
1	0.721191	0.4438	Valid	0.800	Reliable
2	0.933676	0.4438	Valid	0.800	Reliable
3	0.893862	0.4438	Valid	0.800	Reliable

As presented in Table 3, each pretest item obtained an r-value exceeding the critical r-value of 0.4438, confirming the validity of all items. In addition, the obtained Cronbach's alpha value ($\alpha = 0.800$) reflects a satisfactory level of internal consistency for the pretest instrument.

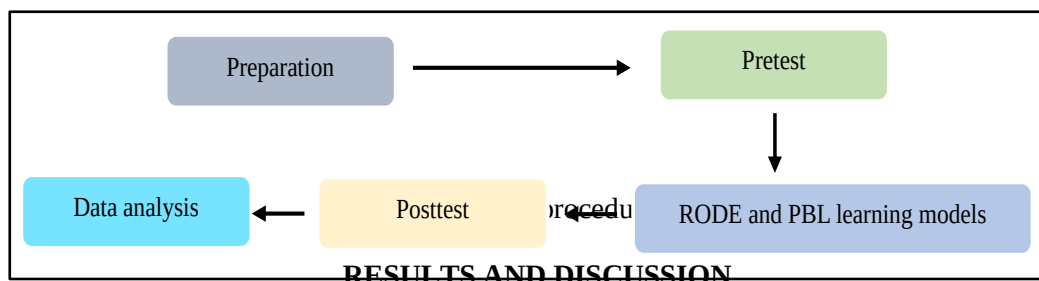
Table 4 Validity and reliability results of the posttest instrument

Item Number	Calculated r	Table r	Category	Reliability (α)	Description
1	0.81514	0.4438	Valid	0.8635	Reliable
2	0.961157	0.4438	Valid	0.8635	Reliable
3	0.890362	0.4438	Valid	0.8635	Reliable

Table 4 demonstrates that each posttest item achieved an r -value exceeding the critical value of 0.4438, thereby meeting the criteria for validity. Moreover, the Cronbach's alpha coefficient ($\alpha = 0.8635$) indicates a high level of internal consistency for the posttest instrument. Following verification of both validity and reliability, the collected data were subsequently processed using suitable analytical techniques.

The data were analyzed through both descriptive and inferential approaches. The descriptive phase aimed to summarize score distributions by presenting measures such as average values, dispersion indices, and the lowest and highest scores obtained from the pretest, posttest, and N-Gain in each group. To determine the level of improvement, the N-Gain scores were interpreted using the following criteria: high ($g \geq 0.70$), moderate ($0.30 \leq g < 0.70$), and low ($g < 0.30$). Prior to hypothesis testing, the normality of the data was examined using the Shapiro–Wilk test at the 0.05 significance level. Since the data did not meet the assumption of normality, differences in the improvement of students' mathematical communication skills between the two groups were analyzed using the nonparametric Mann–Whitney U test. The statistical analyses were performed using IBM SPSS Statistics 26. The hypotheses tested were H_0 : there is no significant difference in the improvement of students' mathematical communication skills between the two groups, and H_1 : there is a significant difference in the improvement of students' mathematical communication skills between the two groups. The decision criterion was that H_0 was rejected if the significance value was less than 0.05. In addition, the group with the higher mean rank was interpreted as the group showing greater improvement.

The study was implemented in a sequence of organized phases. Initially, preparatory activities were conducted, including the development of research instruments, assessment of item validity and reliability, and preparation of teaching materials aligned with the RODE and PBL approaches. Subsequently, an initial assessment was administered to both classes to measure baseline competence. Following this, instructional interventions were applied: the first class received instruction structured according to the RODE approach, whereas the second class participated in learning activities based on the PBL approach. After the intervention period, a final assessment was conducted to evaluate changes in mathematical communication skills. The last phase consisted of statistical analysis, which included calculating N-Gain scores, examining data normality, and applying the Mann–Whitney procedure to compare improvement levels across the two classes. A visual summary of these procedural steps is provided in Figure 1.



The instructional intervention was implemented differently in the two experimental classes. Experimental Group 1 received instruction using the RODE model, which consisted of the stages of Read, Outline, Discussion, and Evaluation. Meanwhile, Experimental Group 2 received instruction using the PBL model, which involved problem orientation, organizing students for learning, guiding investigation, developing and presenting the results, and evaluating the problem-solving process. After the interventions had been completed, students' improvement in mathematical communication skills was examined through the

calculation of N-Gain scores. A summary of the pretest results, posttest outcomes, and N-Gain values for each experimental class is provided in Table 5.

Table 5 Research results data

Group	Pretest Mean	Post-test Mean	N-Gain Mean
Experimental 1	31.43	87.12	0.8290
Experimental 2	41.28	75.75	0.6107

Table 5 shows that both groups improved in mathematical communication skills, as indicated by increases in mean scores and positive N-Gain values. However, the pretest mean of Experimental Group 2 (41.28) was higher than that of Experimental Group 1 (31.43), indicating an initial difference between groups. Because this study employed a quasi-experimental design, the main comparison was based on students' individual N-gain scores to examine relative improvement after the instructional intervention. Based on the N-Gain results, Experimental Group 1 obtained a higher mean N-Gain (0.8290) than Experimental Group 2 (0.6107), indicating greater improvement in the group taught using the RODE model.

Before comparing the improvement between the two groups, the normality of the N-Gain data was tested using the Shapiro–Wilk procedure. The results are presented in Table 6.

Table 6 Normality test results for n-gain data

Group	Shapiro-Wilk Sig.
Experimental 1	0.000
Experimental 2	0.010

The results of the Shapiro–Wilk test showed that the N-Gain scores of Experimental group 1 ($p < 0.001$) and Experimental group 2 ($p = 0.010$) were below the 0.05 significance level, indicating that the data in both groups were not normally distributed. Therefore, the difference in the improvement of students' mathematical communication skills between the two groups was further analyzed using the nonparametric Mann–Whitney U test. The results of this test are presented in Table 7.

Table 7 Mann-Whitney U test results

Group	N	Mean Rank	Sum of Ranks
N-Gain Experimental 1	22	26.34	579.50
N-Gain Experimental 2	22	18.66	410.50
Total	44		
Statistic	Result		
Mann-Whitney U	157.500		
Wilcoxon W	410.500		
Z	-2.070		
Asymp. Sig. (2-tailed)	.038		

The statistical comparison yielded a p-value of 0.038, which is lower than the 0.05 significance level, indicating a significant difference in N-Gain outcomes between the two groups. The mean rank obtained by Experimental group 1 (26.34) was higher than that of Experimental group 2 (18.66), suggesting that the class taught through the RODE approach achieved a greater increase in students' mathematical communication skills than the class instructed through PBL.

The results obtained in this research show that instruction structured through the RODE approach produced a greater increase in mathematical communication skills than

instruction based on PBL. This pattern underscores the significance of systematic instructional organization in facilitating clearer and more coherent expression of mathematical reasoning. Consistent with this perspective, [Hamidah & Kusuma \(2024\)](#) observed that learners with limited communication competence in mathematics are more prone to procedural mistakes, thereby highlighting the value of structured learning phases in strengthening reasoning and communication processes.

The stronger improvement observed in the RODE group may be explained by its systematic learning sequence—Read, Outline, Discussion, and Evaluation—which provides explicit cognitive scaffolding. Through these stages, students are guided to carefully understand problems, organize essential information, articulate their reasoning during discussion, and evaluate their solutions. This guided process encourages logical reasoning and more coherent written communication. [Pasani & Amelia \(2025\)](#) noted that interactive and well-guided learning experiences foster deeper conceptual understanding and clearer mathematical expression. Similarly, [Bina et al. \(2024\)](#) demonstrated that instructional interventions involving active student engagement significantly improve mathematical communication skills.

In addition to instructional structure, meaningful interaction plays a crucial role in developing communication skills. Previous research has shown that guided group discussion contributes to students' ability to communicate mathematical reasoning more effectively ([Kusuma et al., 2022b](#)). During the implementation of the RODE model in this study, students were asked to evaluate peer presentations by assigning scores to presenting groups. The group that received the highest evaluation was recognized as part of the classroom procedure. This activity provided students with opportunities to present their reasoning and respond to peer feedback during discussion. Furthermore, [Lestari et al. \(2025\)](#) reported that students' written mathematical communication is often weaker than their oral communication, underscoring the need for structured support to strengthen systematic problem-solving and written explanation skills. The integration of reading, organizing, discussion, and evaluation stages within the RODE model appears to effectively address this need.

Although the PBL model also contributes to the development of mathematical communication skills, its open-ended nature may not provide sufficient guidance for all learners. Some students may require more structured guidance during collaborative activities. This observation is consistent with studies indicating that the effectiveness of PBL depends largely on the level of active student participation ([Lubis & Rahayu, 2023](#); [Nuranti & Hasratuddin, 2023](#); [Saputri & Wardani, 2021](#); [Yulianti & Gunawan, 2019](#)).

Overall, while both instructional models are capable of improving students' mathematical communication skills, the more systematic structure of the RODE model offers stronger support for organized reasoning and coherent mathematical expression. These findings suggest that RODE may be particularly effective for learning topics that require careful problem interpretation and step-by-step explanation. Nevertheless, PBL remains valuable for fostering creativity, collaborative problem-solving, and exploratory thinking. [Nguyen et al. \(2025\)](#) identified instructional models and strategies as among the most frequently reported factors influencing students' mathematical communication skills, further emphasizing the importance of selecting appropriate learning approaches.

CONCLUSION

Overall, the analysis confirms that both RODE-based and PBL-based instruction contributed to the improvement of students' mathematical communication skills, as reflected in the positive N-Gain scores observed in each class. Nevertheless, the magnitude of improvement differed, with the RODE group achieving a higher mean N-Gain (0.8290)

than the PBL group (0.6107). The statistical comparison revealed a significant difference in favor of the RODE approach, suggesting that this structured instructional strategy yields stronger gains in mathematical communication skills.

The systematic stages of the RODE model—Read, Outline, Discussion, and Evaluation—provide structured guidance that supports students in understanding problems, organizing ideas, articulating reasoning, and evaluating solutions coherently. These findings imply that learning designs integrating clear procedural direction, collaborative exchange, and reflective activities can more effectively improve students' mathematical communication skills compared to approaches that rely on less structured problem exploration.

This research has several limitations that should be acknowledged. The participants were drawn from only two classes in a single school, which means the results cannot be broadly generalized to other contexts. Furthermore, the intervention was confined to the topic of linear equations in one variable and was conducted within a relatively short time frame. Future studies are encouraged to include a wider range of participants from different educational settings, implement the RODE approach in various mathematical topics, and further explore its influence on other mathematical abilities such as problem solving, reasoning, and mathematical literacy.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS STATEMENT

Conceptualization, methodology, formal analysis, writing, and preparation of the original draft: RK; review and supervision: AEK and JBD.

AI DISCLOSURE STATEMENT

The author used ChatGPT for language improvement, as well as Humata AI, QuillBot, and Google Translate for paraphrasing and translation during the preparation of this article. The author also used Publish or Perish and Mendeley for literature searching and reference management. All content was carefully reviewed and edited by the author, who takes full responsibility for the final content of the publication.

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