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Analysis of the Mathematical Communication Skills of Grade XII Vocational High School Students on Linear Programming Material

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Abstract

The low level of students' mathematical communication skills in mathematics learning, particularly in linear programming topics, remains a significant concern. This issue is critical because linear programming requires students to express, represent, and justify mathematical ideas systematically in both written and visual forms. The study aimed to analyze the mathematical communication skills of grade XII vocational high school students based on indicators of oral and written communication, mathematical representation, and reasoning and symbolic thinking. This study employed a qualitative method with a descriptive approach involving 12 students selected purposively. Data were collected through essay tests and in-depth interviews and analyzed through the stages of data reduction, data presentation, and conclusion drawing. The findings revealed that students' mathematical communication skills were still predominantly in the low category, with 6 students categorized as low, 4 as moderate, and 2 as high. Students in the high category were able to construct mathematical models and explain solution procedures systematically, whereas students in the low category experienced difficulties in using symbols, representations, and logical reasoning. The study concludes that students' mathematical communication skills are not yet optimal; therefore, more active, communicative, and contextual learning strategies are needed to improve students' ability to express mathematical ideas systematically.

Keywords

Linear Programming, Mathematical Communication, Mathematical Representation, Reasoning Skills, Vocational High School Students.

1. Introduction

Education is a systematic process that is not only oriented toward the transfer of knowledge but also toward the development of students' thinking and communication skills (Husna et al., 2025). In mathematics learning, communication skills are considered one of the key indicators of learning success, as mathematics functions as a symbolic language that requires precision in expressing ideas (Rasyid, 2019). In line with UNESCO's educational goals, the success of mathematics learning is not only measured by conceptual mastery but also by students' ability to communicate mathematical ideas clearly, logically, and systematically through various representations (Kurniati, 2025).

In classroom practice, students' mathematical communication skills are still often neglected, particularly in relation to indicators such as writing, drawing, and expressing mathematical models. Students tend to focus only on final answers without being able to explain the solution process in written or visual forms (Fitriani et al., 2025). In fact, indicators of mathematical communication, such as identifying known and asked information, explaining solution steps, and drawing conclusions, are essential components of comprehensive conceptual understanding. This condition indicates that mathematics learning has not yet fully developed all indicators of students' mathematical communication skills (Ayyasy & Munadar, 2023).

Mathematical communication skills consist of several interrelated main indicators. According to Lubis and Rahayu (2023), these indicators include the ability to express mathematical ideas in written form, drawings, graphs, and symbols. Maryati et al. (2022) further add that this skill also involves understanding, interpreting, and evaluating mathematical ideas. More specifically, Sunaryo et al. (2024) explain that the indicators of mathematical communication include the ability to write explanations in one's own words, represent mathematical problems visually, translate problems into mathematical models, identify given and asked information, explain solution procedures, and draw conclusions. These indicators serve as important benchmarks for assessing the quality of students' mathematical communication skills.

However, previous studies have shown that the achievement of students' mathematical communication indicators is still not optimal (Rapsanjani & Sritresna, 2021). These studies by Sa'adah and Sumartini (2021) indicate that students' mathematical communication skills are at a moderate level, meaning that not all indicators have been fully achieved. Other research by Widayanti and Anggraeni (2019) also found that students are only able to fulfill some indicators, particularly in the aspects of visual representation and the use of mathematical symbols. This indicates a gap between the theoretical demands of mathematical communication indicators and the actual conditions in the classroom, which are still dominated by teacher-centered learning.

Based on this gap, the present study offers novelty by focusing on a more specific and in-depth analysis of each indicator of mathematical communication skills. Rather than merely examining final outcomes, this study investigates how students write explanations, draw representations, express mathematical models, identify given information, explain solution procedures, and draw conclusions (Sunaryo et al., 2024). This focus is particularly important in linear programming material, which requires the integration of various mathematical communication indicators in solving contextual problems.

The research problem of this study is how the mathematical communication skills of grade XII vocational high school students in linear programming material are viewed from the indicators of mathematical communication, namely the ability to write, draw, express mathematical models, identify information, explain solution steps, and draw conclusions. Accordingly, the aim of this study is to analyze in depth the level of students' achievement in each of these indicators in order to obtain a clear description of students' mathematical communication skills.

The findings of this study are expected to provide important implications for the development of mathematics learning, particularly in improving students' mathematical communication skills. By identifying strengths and weaknesses in each indicator, teachers can design more effective learning strategies, such as encouraging students to actively write, draw, and explain their thinking processes. In addition, this study is also expected to serve as a reference for creating more participatory learning environments that comprehensively foster students' mathematical communication skills.

2. Literature Review

2.1. Writing Ability and Mathematical Representation

Writing ability in mathematical communication is an important indicator that shows how well students can express mathematical ideas, procedures, and solutions in written form using their own language (Hutapea, 2025). Maryati et al. (2022) emphasize that mathematical communication is not limited to obtaining correct answers but also involves the ability to explain solution steps in a coherent and logical sequence. In line with this, Sunaryo et al. (2024) state that writing ability includes explaining ideas, constructing mathematical arguments, and presenting solutions in a systematic manner. In the context of linear programming material, this ability is essential because students are required to describe the modeling process, determine objective functions, and interpret the results clearly in written form.

However, previous studies show that students' writing ability in mathematics is still generally at a low to moderate level, particularly in providing complete explanations of solution procedures (Sa'adah & Sumartini, 2021; Suroto et al., 2023). This condition is influenced by learning practices that tend to focus more on final answers rather than the problem-solving process (Fitriani & Ilyas, 2019; Hidayani et al., 2023). Therefore, improving students' writing and representation skills in mathematical communication is necessary through learning activities that encourage them to express reasoning, models, and solutions in a structured and meaningful way.

2.2. Drawing Skills and Visual Representation

Visual representation ability is one of the important indicators of mathematical communication that refers to students' capacity to present mathematical ideas in the form of graphs, diagrams, or drawings. Lubis and Rahayu (2023) state that this ability involves the skill of connecting real-life situations with visual mathematical representations. In mathematics learning, particularly in linear programming material, visual representation is highly essential because students are required to graph linear inequalities, determine feasible solution regions, and interpret solutions visually (Monariska & Komala, 2021). Through visual representations, students can more easily understand relationships between variables and observe problem solutions in a more concrete manner.

However, previous studies indicate that students still experience difficulties in constructing and interpreting graphs accurately. Widayanti and Anggraeni (2019) found that common errors include determining intercept points, shading the correct solution region, and interpreting the meaning of graphical representations. These difficulties suggest that the indicator of visual representation ability has not yet developed optimally in mathematics learning. This condition highlights the need for stronger emphasis on improving students' visual communication skills through learning activities that provide more opportunities to practice drawing graphs, analyzing visual data, and linking representations with real-world contexts in a more meaningful and systematic way (Rapsanjani & Sritresna, 2021).

2.3. Mathematical Expression and Conclusion Drawing Skills

Mathematical expression ability is an important indicator of mathematical communication that relates to students' ability to transform contextual problems into mathematical models and to use symbols and notations accurately. Rahmalia and Ansari (2020) state that this ability reflects students' skills in constructing mathematical models from real-life situations. In addition, this indicator also includes the ability to identify given and asked information, explain solution procedures, and draw appropriate conclusions (Sunaryo et al., 2024). In the context of linear programming material, this ability is highly crucial because students are required to formulate mathematical models from contextual problems and determine optimal solutions based on those models. Through this process, students are expected to demonstrate logical thinking in translating verbal problems into mathematical representations.

However, in practice, many students still experience difficulties in converting contextual problems into mathematical models and in drawing conclusions that are consistent with the context of the questions (Aspia et al., 2025). Students often struggle to determine relevant variables, construct correct equations, and interpret final results appropriately. These difficulties indicate that mathematical expression ability and conclusion-drawing skills have not yet developed optimally. This situation highlights the importance of strengthening students' understanding through learning activities that emphasize problem modeling, symbolic representation, and interpretation of results. Such efforts are essential to help students connect contextual problems with mathematical models more accurately and meaningfully in linear programming learning.

3. Methods

This study uses a qualitative research type with a descriptive approach, which aims to understand in depth students' mathematical communication skills based on measurable indicators in the process of solving linear programming problems (Sugiyono, 2019). This approach was chosen because it is able to describe phenomena contextually and comprehensively, especially in examining how students write, represent, and express their mathematical ideas (Setiawan et al., 2024). The study was conducted at SMK Darul Fattah Way Bungur in the odd semester of the 2025/2026 academic year with 12 grade XII students selected purposively to represent the variety of abilities. The data used were primary data, obtained through written tests and in-depth interviews.

The descriptive test was used to identify mathematical communication skills based on indicators of oral and written communication, mathematical representation, and reasoning and symbolic reasoning, while interviews were used to strengthen and deepen the results of students' answers. The choice of this method is urgent because mathematical communication skills cannot be measured only from the final results, but need to be analyzed through students' comprehensive thinking processes. Data analysis techniques were carried out through the stages of data reduction, data presentation, and drawing conclusions by correcting, identifying, and classifying student answers based on mathematical communication indicators, then synchronizing test results with interview results to obtain a valid picture (Sukaesih et al., 2020).

Based on the mathematical communication skills test instrument presented in Table 1, it can be concluded that this study focuses on three main indicators, namely oral and written communication, mathematical representation, and reasoning and symbolic thinking. These three indicators are used to comprehensively measure students' abilities in expressing mathematical ideas in written form, presenting them visually, and constructing models and logical reasoning in solving linear programming problems. Thus, the instrument used not only assesses students' final answers, but also examines the mathematical thinking process that reflects their mathematical communication skills in a more comprehensive manner.

Table 1. Mathematical Communication Skills Test Instrument

No	Indicator of Mathematical Communication Skills	Indicator Description	Item
1	Oral and Written Communication	Able to write a mathematical model and explain the solution process in a coherent and logical manner	A printing company has a fixed cost of IDR 1,200,000 and a variable cost of IDR 8,000 per book, with a selling price of IDR 15,000. Construct a linear equation model for profit (K) based on the number of books (x), explain the steps in developing the model, and interpret the meaning of each component in the model.
2	Mathematical Representation	Able to present mathematical ideas in tables and graphs and interpret them	Given the equation $y = 2x + 1$, construct a value table for five different x values, draw its graph, and explain the linear relationship between x and y based on the graph.
3	Reasoning and Symbolic Thinking	Able to construct a mathematical model from a contextual problem, explain logical steps, and draw conclusions	Machine A produces 1 item per 4 minutes, and Machine B produces 1 item per 6 minutes. Formulate an equation for total production in t minutes, determine when both machines produce the same output, and explain the solution steps logically.

4. Results

4.1. Results of Mathematical Communication Skills Assessment

The students' mathematical communication skills data were obtained through essay tests consisting of three questions and in-depth interviews to strengthen the analysis results. The test was designed to measure three main indicators of mathematical communication skills, namely oral and written communication, mathematical representation, and reasoning and symbolic thinking. These indicators were used to examine students' abilities not only based on their final answers, but also on the mathematical thinking processes demonstrated in solving linear programming problems. The assessment of students' mathematical communication skills was carried out using a rubric that includes aspects of model correctness, accuracy of representation, logical reasoning, and the appropriate use of mathematical notation. The scoring rubric used is presented as follows in Table 2.

Table 2. Scoring Rubric for Mathematical Communication Skills Test

Question	Assessment Component	Description	Score	Total Score
1	Correctness of Model	The linear model is correct and properly simplified	15	40
	Systematic Steps	Revenue, cost, and profit are explained in a logical sequence	12	
	Interpretation of Coefficients	The meaning of fixed cost, variable cost, and selling price is explained	8	
	Notation & Units	Correct notation and complete units are used	5	
2	Value Table	Five correct (x, y) pairs are provided	10	25
	Graph	Correct plotting of points and linear graph explanation	7	
	Linear Relationship	Interpretation of slope and intercept is provided	6	
	Notation	Clear and appropriate notation is used	2	
3	Linear Model	The correct equation for total production in t is formulated	12	35
	Equation Solving	Correct determination of when outputs are equal	12	
	Reasoning	Logical and systematic solution steps are provided	8	
	Notation & Units	Correct notation and time unit (minutes) are used	3	
Total Score				100

Table 2 describes the scoring rubric applied to measure students' mathematical communication skills through three essay-based questions, with a total possible score of 100. Question 1 carries a maximum score of 40, which includes assessment of the accuracy of the mathematical model (15 points), the coherence of solution procedures (12 points), interpretation of coefficients (8 points), and the use of correct notation and units (5 points). Question 2 contributes a maximum of 25 points, covering the construction of value tables (10 points), graph representation (7 points), interpretation of linear relationships (6 points), and appropriate notation usage (2 points). In addition, question 3 has a maximum score of 35, consisting of the formulation of the linear model (12 points), equation solving (12 points), logical reasoning (8 points), and notation and units (3 points). The rubric is designed to comprehensively evaluate students' abilities in mathematical representation, reasoning, modeling, and systematic communication of mathematical ideas.

Table 3. Data on Subject Score Results

Subject	Question 1	Question 2	Question 3	Total Score	Category
1	20	18	25	63	Moderate
2	30	20	23	73	Moderate
3	18	15	22	55	Low
4	16	14	20	50	Low
5	38	20	32	90	High
6	14	12	18	44	Low
7	25	22	30	77	Moderate
8	17	15	23	55	Low
9	19	17	21	57	Low
10	18	10	9	37	Low
11	38	24	34	96	High
12	21	18	24	63	Moderate

Table 3 displays the students' scores on the mathematical communication skills test based on the results of the three essay questions. The findings indicate differences in students' achievement levels across the assessed indicators. Among the 12 subjects, 2 students were included in the high category, specifically subject 5 with a total score of 90 and subject 11 with a score of 96. In addition, 4 students were classified in the moderate category with scores ranging from 63 to 77, while the remaining 6 students were categorized as low, obtaining scores between 37 and 57. The results suggest that students' mathematical communication skills are still predominantly at the low level, especially in explaining mathematical ideas, representing solutions, and demonstrating logical reasoning systematically.

Table 4. Students' Scores After Being Organized by Category

Subject	Question 1	Question 2	Question 3	Total Score	Category
5	38	20	32	90	High
11	38	24	34	96	High
2	30	20	23	73	Moderate
7	25	22	30	77	Moderate
1	20	18	25	63	Moderate
12	21	18	24	63	Moderate
9	19	17	21	57	Low
3	18	15	22	55	Low
8	17	15	23	55	Low
4	16	14	20	50	Low
6	14	12	18	44	Low
10	18	10	9	37	Low

Table 4 illustrates the classification of students' mathematical communication skills based on their total scores. The findings indicate that only 2 students reached the high category, namely subject 5 with a score of 90 and subject 11 with 96. In the moderate category, there were 4 students whose scores ranged from 63 to 77. Meanwhile, the largest number of students, consisting of 6 subjects, belonged to the low category, with scores between 37 and 57. These results suggest that most students still have limited mathematical communication skills, particularly in expressing mathematical ideas clearly, interpreting representations, and providing logical explanations in problem-solving processes.

4.2. Analysis of Results by Category

At the high category level with a score of 96, the student demonstrated excellent conceptual mastery in solving linear programming problems. The student was able to construct mathematical models accurately, explain solution steps in a coherent sequence, and use mathematical representations correctly. This indicates that the student has been able to integrate oral and written communication, mathematical representation, and symbolic reasoning optimally. According to Mulyadi and Manoy (2022), this ability reflects students' skills in transforming problem situations into more concrete mathematical forms. The student also showed strong conceptual understanding of profit, linear equations, straight-line graphs, and machine production rates. However, there was a minor limitation in the form of insufficiently deep contextual explanation of the final results (Maulani et al., 2025). The errors that appeared were mostly technical and related to carelessness rather than a lack of conceptual understanding (Pratiwi et al., 2025).

At the moderate category level with a score of 73, the student has demonstrated an understanding of basic concepts such as linear equations and graphs, but has not yet been able to communicate mathematical ideas completely. The explanation of coefficients and mathematical models remains simple and lacks depth (Sri & Nst, 2024). Students also tend to focus more on the final answer rather than the solution process itself. In terms of mathematical representation, the student is able to construct tables and graphs; however, the interpretation of relationships between representations is still weak (Riyadi et al., 2021). In addition, mathematical reasoning has begun to emerge but is not yet supported by strong logical arguments (Nabilah & Rohmah, 2024). This condition indicates that students' mathematical communication skills still require further strengthening, particularly in explaining their thinking processes in a systematic and coherent manner (Dalimunthe et al., 2023).

At the low category level with a score of 37, the student demonstrates a very limited understanding of mathematical concepts. Numerous errors occur in constructing mathematical models, using symbols, and performing solution steps in a non-systematic manner (Johar & Lubis, 2018). The student also has not yet understood basic concepts of profit and linear programming representation correctly. Mathematical representation skills are also weak, as shown by the inability to construct tables and graphs appropriately. In addition, mathematical reasoning is very weak because answers are not accompanied by logical justification or adequate explanation (Hidayati, 2022). This indicates that students in the low category require learning that places greater emphasis on basic conceptual understanding and gradual practice in mathematical communication skills. The results of the study show that the mathematical communication skills of grade XII vocational high school students in linear programming material are still dominated by the low category. This is evident from students' limited ability to integrate oral and written communication, mathematical representation, and symbolic reasoning comprehensively in solving problems.

5. Discussion

The results of the study indicate that the mathematical communication skills of grade XII vocational high school students in linear programming material vary and are still predominantly categorized as low. Based on the results of essay tests and interviews, most students have not been able to fully integrate the three main indicators of mathematical communication, namely oral and written communication, mathematical representation, and reasoning and symbolic thinking. Many students were only able to provide direct answers without explaining the reasoning process systematically and coherently. This finding suggests that mathematical communication skills have not yet become a major focus in classroom learning activities. According to Rapsanjani and Sritresna (2021), students' mathematical communication skills are generally still at a moderate to low level because learning practices tend to emphasize final answers rather than reasoning processes. Similarly, Sa'adah and Sumartini (2021) explain that students often experience difficulties in expressing mathematical ideas clearly and systematically in written form.

Students in the high category demonstrated strong conceptual understanding of linear programming material. They were able to construct mathematical models correctly, explain solution procedures in a coherent manner, and use representations such as tables and graphs appropriately. In addition, these students showed better abilities in connecting symbolic expressions with contextual problems. Such findings indicate that students with high mathematical communication skills are capable of integrating representation, reasoning, and explanation effectively. Mulyadi and Manoy (2022) state that students with strong communication skills generally have the ability to transform abstract mathematical problems into more concrete forms through appropriate representations. However, although students in this category performed well, there were still minor weaknesses related to providing deeper contextual interpretations of the results obtained. Maulani et al. (2025) argue that students often focus more on procedural accuracy than on relating mathematical solutions to real-life contexts. Therefore, contextual explanation remains an important aspect that should continue to be strengthened in mathematics learning.

Meanwhile, students in the moderate category showed sufficient understanding of basic concepts such as linear equations, graphs, and simple mathematical models. Nevertheless, their communication skills were still not fully developed. Their explanations tended to be brief, less systematic, and lacking in detailed reasoning. In the aspect of mathematical representation, students were generally able to construct tables and graphs correctly, but they still faced difficulties in explaining the relationships between different representations. Riyadi et al. (2021) explain that students frequently experience challenges in interpreting visual representations and connecting them with symbolic forms. In addition, the mathematical reasoning demonstrated by these students was often not supported by complete logical justification.

At the low category level, students experienced significant difficulties in understanding and solving linear programming problems. Many students were unable to formulate correct mathematical models, made errors in the use of symbols and notation, and failed to explain solution procedures systematically. Their abilities in constructing tables, drawing graphs, and applying logical reasoning were also very limited. Johar and Lubis (2018) found that students with low mathematical communication skills often struggle with identifying relevant information and translating contextual problems into mathematical expressions. Similarly, Hidayati (2022) explains that weak reasoning abilities are commonly reflected in incomplete explanations and the absence of logical arguments in students' answers. These findings suggest that students in the low category have not yet mastered the fundamental concepts needed to communicate mathematical ideas effectively.

The findings of this study demonstrate that students' mathematical communication skills still need substantial improvement, particularly in mathematical representation and symbolic reasoning. Current classroom practices have not fully provided opportunities for students to express their thinking processes orally and in written form. According to Maryati et al. (2022), effective mathematics learning should encourage students to actively explain, represent, and justify their mathematical ideas during the problem-solving process. Therefore, more active, contextual, and communicative learning strategies are necessary to help students develop their mathematical communication skills comprehensively in solving linear programming problems.

6. Conclusion

Based on the findings of the study, it can be concluded that the mathematical communication skills of grade XII vocational high school students in linear programming material are still predominantly categorized as low. Most students have not been able to fully integrate oral and written communication, mathematical representation, reasoning, and symbolic thinking in solving mathematical problems. Students in the high category were able to construct mathematical models, use representations appropriately, and explain solution procedures systematically, while students in the moderate category still showed weaknesses in providing structured explanations and connecting different mathematical representations. Meanwhile, students in the low category experienced difficulties in understanding basic concepts, using mathematical symbols correctly, and explaining solution processes logically. These findings indicate that mathematics learning still needs to place greater emphasis on strengthening students' mathematical communication skills through more active, communicative, and contextual learning activities that encourage students to express mathematical ideas clearly and systematically.

This study has several limitations, including the relatively small number of participants and the focus on linear programming material within a single educational level, which limits the generalizability of the findings. In addition, this study employed a descriptive qualitative approach that emphasized in-depth analysis of students' abilities without examining the effects of specific instructional strategies. Therefore, future research is recommended to involve larger samples, apply mixed-method or experimental approaches, and develop instructional models aimed at improving students' mathematical communication skills across various mathematical topics.

References

Aspia, S., Rismunandar, S. A., Ratnaningsih, N., & Siliwangi, U. (2025). Analisis kesulitan siswa dalam menerjemahkan soal cerita ke dalam model matematika pada materi perbandingan. *Jurnal Matematika dan Ilmu Pengetahuan Alam*, *6*(4), 101–109.

Ayyasy, L., & Munandar, D. R. (2023). Kemampuan komunikasi matematis siswa dalam pembelajaran matematika. *Jurnal Educatio*, *9*(2), 1100–1107. https://doi.org/10.31949/educatio.v9i2.5049.

Dalimunthe, Y., Dalimunthe, S. Z., & Hasibuan, I. S. (2023). Analysis of students' mathematical communication ability based on self-regulated learning. *Journal of Medives: Journal of Mathematics Education IKIP Veteran Semarang*, *7*(1), 86–92. https://doi.org/10.31331/medivesveteran.v7i1.2323.

Fitriani, Abin, R., Suryadi, R., Syam, H., Reskiawan, B., & Sultan. (2025). The impact of reading, covering, remembering, retelling on students' reading comprehension. *Research Horizon*, *5*(3), 1029–1038. https://doi.org/10.54518/rh.5.3.2025.568.

Fitriani, S., & Ilyas, H. P. (2019). Communication skill: A challenge for vocational high school students in the 21st century. *Jurnal Solma*, *8*(1), 150-180. https://doi.org/10.29405/solma.v8i1.3097.

Hidayani, S., Silfani, A. N., & Razali, K. (2023). A pragmatic approach in teaching speaking skills for vocational high school students. *Loquen: English Studies Journal*, *16*(1), 67–74. https://doi.org/10.32678/loquen.v16i1.8762.

Hidayati, N. (2022). Analisis kesulitan siswa berdasarkan kemampuan pemahaman konsep matematis dalam menyelesaikan soal materi SPLDV. *Jurnal Cendekia*, *6*(1), 24–34. https://doi.org/10.31004/cendekia.v6i1.981.

Husna, A., Ilmi, N., & Gusmaneli, G. (2025). Strategi pembelajaran berbasis masalah dalam meningkatkan kemampuan berpikir kritis peserta didik. *Katalis Pendidikan: Jurnal Ilmu Pendidikan dan Matematika*, *2*(2), 76–78. https://doi.org/10.62383/katalis.v2i2.1532.

Hutapea, N. M. (2025). Analisis kemampuan komunikasi matematis siswa pada materi statistika. *Lattice Journal: Journal of Mathematics Education and Applied*, *5*(1), 14–28. https://doi.org/10.30983/lattice.v5i1.9504.

Johar, R., & Lubis, K. R. (2018). The analysis of students' mathematical representation errors in solving word problems related to graph. *Jurnal Riset Pendidikan Matematika*, *5*(1), 96–107. https://doi.org/10.21831/jrpm.v5i1.17277

Kurniati, R., Dahlan, T., Madubun, F. M., Afifa, R. N., Dahoklory, F. M., Dahliani, S., & Lubis, H. (2025). *Pendidikan matematika*. Sumatera Barat: Yayasan Tri Edukasi Ilmiah.

Lubis, R. N., & Rahayu, W. (2023). Kemampuan komunikasi matematis siswa pada pembelajaran matematika. *Jurnal Riset Pembelajaran Matematika Sekolah*, *7*(2), 23-34. https://doi.org/10.21009/jrpms.072.03.

Maryati, I., Suzana, Y., Harefa, D., & Maulana, I. T. (2022). Analisis kemampuan komunikasi matematis dalam materi aljabar linier. *PRISMA*, *11*(1), 210-222. https://doi.org/10.35194/jp.v11i1.2044.

Maulani, N., Muhtadi, D., Siliwangi, U., & Barat, J. (2025). Analisis kesulitan siswa dalam kemampuan komunikasi matematis pada materi persamaan garis lurus. *Uninus Journal of Mathematics Education and Science*, *10*(1), 31–41. https://doi.org/10.30999/ujmes.v10i1.3586.

Monariska, E., & Komala, E. (2021). Analisis kemampuan representasi matematis mahasiswa pada mata kuliah program linear. *Jurnal Edukasi dan Sains Matematika (JES-MAT)*, *7*(1), 43-58.

Mulyadi, N. A., & Manoy, J. T. (2022). Representasi siswa dengan kemampuan matematis tinggi dalam memecahkan masalah matematika. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, *6*(1), 533–546. https://doi.org/10.31004/cendekia.v6i1.1281.

Nabilah, N., & Rohmah, S. (2024). Matematis siswa pada materi peluang melalui self-efficacy. *Jurnal Ilmiah Pendidikan Matematika*, *9*(2), 305–313. https://doi.org/10.26877/jipmat.v9i2.1084

Pratiwi, A., Suryadi, R., Astiantih, S., Sultan, Putra, E., Syahria, N., & Naing, I. R. (2025). The effect of learning styles on vocabulary mastery among second-year students. *Research Horizon*, *5*(3), 717–728. https://doi.org/10.54518/rh.5.3.2025.577.

Rahmalia, R., & Ansari, B. (2020). Matematis siswa SMP melalui model problem based learning. *Journal of Numeracy*, *7*(1), 1-12. https://doi.org/10.46244/numeracy.v7i1.1038.

Rapsanjani, D. M., & Sritresna, T. (2021). Kemampuan komunikasi matematis ditinjau dari self-efficacy siswa. *Jurnal Pendidikan Matematika*, *1*(3), 481–492. https://doi.org/10.31980/plusminus.v1i3.1453.

Rasyid, M. A. (2019). Kemampuan komunikasi matematis dalam pembelajaran matematika. *Jurnal Edukasi*, *5*(1), 77–86. https://doi.org/10.51836/je.v5i1.116.

Riyadi, S., Noviartati, K., & Abidin, Z. (2021). Kemampuan komunikasi matematis tulis siswa dalam memecahkan masalah geometri. *Ethnomathematics Journal*, *2*(1), 31–37. https://doi.org/10.21831/ej.v2i1.36192.

Sa'adah, N. R., & Sumartini, T. S. (2021). Kemampuan komunikasi matematis siswa SMP pada materi statistika. *Plusminus: Jurnal Pendidikan Matematika*, *1*(3), 505–518. https://doi.org/10.31980/plusminus.v1i3.958.

Setiawan, W. D., Yollandara, F., & Andika, R. (2024). Analisis indikator kemampuan komunikasi matematis: Kajian kepustakaan. *Jurnal Media Akademik*, *2*(12), 1200-1222. https://doi.org/10.62281/v2i12.1369.

Sri, F., & Nst, W. (2024). Kemampuan komunikasi matematik siswa dengan model pembelajaran kooperatif. *Journal of Education and Science*, *1*(2), 98–105. https://doi.org/10.57255/edusain.u1i1.17.

Sugiyono. (2019). *Metode penelitian kualitatif, kuantitatif, dan R&D*. Bogor: Alfabeta.

Sukaesih, E. S., Indiati, I., & Purwosetiyono, F. X. D. (2020). Kemampuan pemahaman konsep matematis siswa dalam memecahkan masalah kontekstual ditinjau dari komunikasi matematis siswa. *Imajiner: Jurnal Matematika dan Pendidikan Matematika*, *2*(4), 310–320.

Sunaryo, Y., Waluya, S. B., Rachmani, N., & Wijayanti, K. (2024). Literatur review: Indikator kemampuan komunikasi matematis. *PRISMA*, *7*(9), 928–935.

Suroto, S., I Komang, W., Pargito, P., Sukirlan, M., Rangga, F., & Abdul, R. (2023). Communication skills and their relation to transferable skills for vocational high school students. *Journal of Economics Education and Entrepreneurship (JEE)*, *4*(1), 1–7. https://doi.org/10.20527/jee.v4i1.8017.

Widayanti, E., & Anggraeni, S. A. (2019). Analisis kemampuan komunikasi matematis siswa dalam menyelesaikan soal open ended. *Transformasi: Jurnal Pendidikan Matematika*, *3*(2), 115–128. https://doi.org/10.36526/tr.v3i02.754.

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