2025, 6(1), 14–24

Journal of Didactic Mathematics
https://doi.org/ 10.34007/jdm.v6i1.2587

Mathematical communication skills of students in agricultural-based regions: Proficiency levels, challenges, and instructional strategies

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Abstract.
Mathematical communication is a fundamental skill that enables students to express and justify mathematical ideas clearly. This study examines students' mathematical communication skills in an agricultural-based region, focusing on proficiency levels and influencing factors. Using a qualitative case study approach, data were collected from 21 eighth-grade students through problem-solving tasks assessing three key indicators: mathematical modeling, explanation of mathematical patterns, and question formulation. The results indicate that most students exhibit moderate mathematical communication abilities, with only a small proportion demonstrating high proficiency. High-ability students effectively integrate multiple representations and justify their reasoning, while moderate-ability students rely on procedural approaches with limited conceptual depth. Low-ability students face significant challenges in constructing mathematical models and articulating solutions. These findings suggest that contextual factors, including limited access to quality education and instructional strategies, impact students' mathematical communication development. Although students in agricultural communities engage with quantitative reasoning in real-life contexts, they struggle to translate these experiences into formal mathematical communication. The study highlights the need for differentiated instructional strategies, including explicit reasoning exercises and contextualized learning, to enhance students' communication skills. However, the study's limited scope and sample size necessitate further research across diverse regions to explore long-term interventions. Future studies should investigate culturally relevant pedagogical approaches to strengthen mathematical communication, particularly for students in rural and agricultural settings.

Keywords:
Mathematical communication; problem-solving; mathematical literacy; agricultural-based region; instructional strategies

How to cite:
Salido, A., Kausar, A., Aswin, A., & Marniati, M. (2025). Mathematical communication skills of students in agricultural-based regions: Proficiency levels, challenges, and instructional strategies. *Journal of Didactic Mathematics*, *6*(1), 14–24. https://doi.org/ 10.34007/jdm.v6i1.2587

INTRODUCTION

Mathematical communication is a fundamental skill in mathematics education that enables students to express and manipulate mathematical ideas, such as algebraic expressions, geometric theorems, and statistical relationships, clearly and logically. This ability involves the use of mathematical vocabulary, notation, and structures to convey concepts and relationships effectively (Firdaus, 2016). Beyond facilitating conceptual understanding, mathematical communication allows students to present arguments and solutions in a structured manner. The National Council of Teachers of Mathematics (NCTM) emphasizes its crucial role in deepening mathematical comprehension through both verbal and non-verbal interactions (NCTM, 2000). As a core

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Received: 13 February 2025; Revised: 20 March 2025; Accepted: 16 April 2025
2721-5601/

component of mathematical thinking, this skill also significantly contributes to the development of effective problem-solving abilities (Umar, 2012).

Mathematical communication extends beyond verbal or written explanations; it also encompasses the ability to represent mathematical ideas in various forms, such as symbols, diagrams, and mathematical models (Sutopo & Waluya, 2023). Several studies highlight its role in enhancing conceptual understanding, fostering reflective thinking, and developing problem-solving strategies (Lutfianannisak & Sholihah, 2018; Maulyda et al., 2020). Students with strong mathematical communication skills tend to grasp mathematical concepts more easily and articulate their solutions more systematically (Samawati & Ekawati, 2021; Zulhelmi & Anwar, 2021). Conversely, deficiencies in this skill may lead to difficulties in comprehending complex mathematical concepts, ultimately hindering students' overall academic development (Saidah & Mardiani, 2021).

Despite its importance, not all students exhibit optimal mathematical communication skills, particularly those in rural and agricultural-based regions. Environmental and regional factors significantly influence the development of these skills, especially in areas with limited access to quality education and where socio-economic challenges are prevalent (Palinussa et al., 2021). In agricultural regions, additional factors such as limited access to technology and cultural attitudes toward education can exacerbate these challenges (Ikram & Rosidah, 2020). For example, students in rural settings often face difficulties using modern learning tools and online resources, which are essential for developing mathematical communication skills (Whannell & Tobias, 2015). Furthermore, the lack of well-trained teachers who can effectively foster these skills may contribute to lower levels of mathematical proficiency (Anisa et al., 2023).

The 2022 Programme for International Student Assessment (PISA) results further highlight the significance of these challenges. Indonesia's average mathematics score declined from 379 in the previous cycle to 366, placing it 106 points below the global average (OECD, 2023). This decline in mathematics performance can be attributed, in part, to inadequate mathematical communication skills, as students struggle to express their reasoning and solve problems effectively. Moreover, only 18.35% of Indonesian students reached at least Level 2 in mathematics proficiency, compared to the OECD average of 68.91%. Research by Rohid et al. (2019) and Samawati and Ekawati (2021) further indicates that many students struggle with mathematical communication, such as articulating solutions and reasoning clearly. These findings underscore the persistent gap in mathematics proficiency, particularly in rural and agricultural regions where educational infrastructure and learning resources remain insufficient. The limited development of mathematical communication skills in these areas hinders students' ability to understand and apply mathematical concepts effectively, posing additional challenges to their academic achievement and future career prospects (Rohid et al., 2019). Addressing these challenges requires supporting facilities and professional development for teachers, which are tailored to regional needs, to help them support the development of mathematical communication skills in students (Dossett et al., 2019; Puspa et al., 2019).

Previous research has examined mathematical communication skills from various perspectives, such as teaching methods and influencing factors. For example, Sugandi and Bernard (2018) compared contextual and conventional teaching methods, concluding that contextual learning significantly enhances students' mathematical communication skills. Similarly, Ismayanti and Sofyan (2021) and Khadijah et al. (2018) found that students in certain regions exhibit relatively low mathematical communication abilities, particularly in data representation and problem-solving. However, existing studies have not specifically examined how the characteristics of agricultural-based regions with limited access to quality education and learning culture affect students' mathematical communication skills. As a result, a research gap remains regarding the environmental and cultural factors that shape the development of this skill in such areas.

This study addresses this gap by providing an in-depth analysis of students' mathematical communication skills in agricultural-based regions and identifying the factors influencing their development. Unlike previous studies focusing mainly on instructional approaches, this research adopts a qualitative approach to assess students' communication skills, using specific indicators such as the ability to represent mathematical ideas through diagrams, symbols, and written explanations. The study explores environmental factors, such as limited access to resources, cultural attitudes toward education, and the relevance of mathematical content to students' daily lives. The findings aim to inform the development of contextualized teaching strategies, such as integrating agricultural problems into lessons, to make mathematics more relevant and engaging for students, ultimately improving their understanding and communication skills.

METHOD

This study employed a qualitative case study approach with observations, where the researcher administered a series of mathematical communication problem-solving tasks after the teacher had delivered the lesson. The research was conducted in an eighth-grade class at a junior high school in Bandung district, Indonesia, with 21 student participants. The class selection was determined through purposive sampling based on recommendations and considerations from the teacher. Meanwhile, the research site was chosen based on its location in an agricultural area, with limited access to education and a unique learning culture that could influence students' learning experiences. Agricultural areas with such characteristics require further exploration to understand better how students' mathematical communication skills develop within these contexts. This approach enabled an in-depth exploration of students' mathematical communication skills within their natural learning environment, aligning with the qualitative paradigm that emphasizes understanding phenomena in context (Beding, 2017; Beery, 2010).

The research instrument consisted of an essay-based mathematical communication task designed to assess students' abilities through three key indicators: (1) expressing mathematical situations or real-life events in mathematical models and solving them, (2) providing explanations for mathematical models and patterns, and (3) formulating questions related to the given situation along with justifications. The communication task consisted of two questions tested for construct validity through expert judgment by experts from two lecturers and one teacher. This validation method ensured the tasks were appropriate for measuring the intended skills. The task was given after the lesson to evaluate how students applied their mathematical communication skills in problem-solving tasks. The students' task completion results were analyzed based on these indicators and interpreted using descriptive analysis to identify patterns and variations in their mathematical communication abilities.

Data collection occurred over four sessions: three during lessons and one during the problem-solving task. The observations were conducted per specific observation guidelines, ensuring consistency in collecting data across different sessions. The interaction between the researcher and participants was limited to observing students' problem-solving processes and noting their communication during the task to avoid influencing their natural responses. Multiple methods were employed to ensure the reliability of the data, including triangulation of data sources, such as students' task sheets and field notes, to cross-verify the consistency of the findings.

Furthermore, participants were categorized into three ability levels: high, moderate, and low, based on their performance in the mathematical communication task, specifically their ability to clearly express mathematical reasoning, provide coherent explanations, and use appropriate mathematical models. The categorization was determined by scoring their responses according to a predefined rubric that assessed clarity, accuracy, and depth of reasoning. This classification allowed for a comparative analysis of students' mathematical communication skills across different proficiency levels. Each student's responses were examined within their respective groups to explore variations in their problem-solving approaches, reasoning processes, and ability to communicate mathematical concepts effectively.

Data analysis involved several stages: presentation of data, which included presenting all students' problem-solving results and observational findings; data reduction, focusing on selecting and simplifying information relevant to the research objectives; data interpretation, synthesizing findings into a coherent narrative with an emphasis on identifying students' mathematical communication abilities and the factors influencing them; and conclusion, analyzing relationships between findings and proposing strategies to improve students' mathematical communication skills (Miles et al., 2014; Sanjani et al., 2024). Data triangulation was applied to ensure consistency and validity by cross-checking the information from students' task sheets and field notes.

RESULTS AND DISCUSSION

The findings of the study show that the majority of students are at a moderate level of mathematical communication skills. The categorization of students' mathematical communication skills is presented in Table 1.

Table 1. Summary of students' mathematical communication skills

Classification	Score Range	Number of Students (n = 21)
High	≥ 75	5
Moderate	40 – 74	13
Low	≤ 39	3
Mean Score	61,10	

Table 1 shows that the average mathematical communication skill score of the 21 students was 61.10. Based on the skill categorization, five students were classified as high, 13 as moderate, and three as low. The score ranges for high, moderate, and low categories were determined based on data analysis, where the distribution of scores was examined to establish a meaningful classification. The categorization reflects the overall performance of the students about the task's expectations and the specific criteria used to assess mathematical communication skills.

The students' responses in each group revealed differences in problem-solving strategies, reflecting their mathematical communication skills. An example of a student's response from the high-ability group, represented by S-01, for the first task is presented in Figure 1.

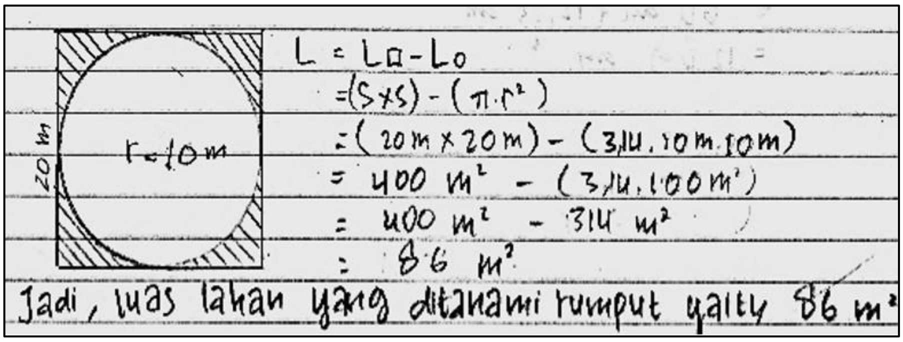

Figure 1. Response of the high-ability group (S-01) on the first task

Figure 1 illustrates the proficiency of the high-ability group in completing the first task. In solving Task 1, S-01 began by articulating the given mathematical situation. Subsequently, the student formulated a mathematical model by integrating multiple equations and relevant mathematical concepts. The problem-solving steps were carried out simultaneously within the constructed model. In the final solution, S-01 provided a correct answer, including appropriate units and a clear conclusion. In the moderate-ability group, a similar problem-solving approach was observed; however, errors were present in the final answer. An example of a student's response from the moderate-ability group, represented by S-02, for the first task is presented in Figure 2.

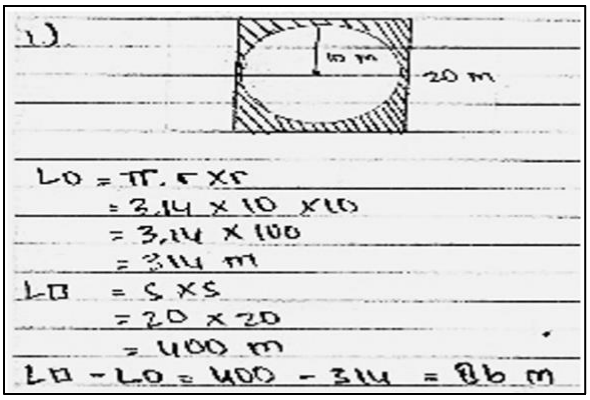

Figure 2. Response of the moderate-ability group (S-02) on the first task

Figure 2 shows that student S-02 obtained the same numerical result as S-01 but made an error in writing the unit of area. In the problem-solving process, S-02 employed a different approach by completing each step separately. The student first determined the area of the circular region, followed by the area of the square region. After calculating both areas, S-02 determined the shaded area by subtracting the area of the circle from that of the square. While the overall strategy used by S-02 was appropriate, an error occurred in the notation of the area unit. In contrast, students in the low-ability group encountered significant difficulties in completing this task. Represented by S-03, they demonstrated an inability to construct a mathematical model based on the given problem, as illustrated in Figure 3. In this figure, S-03 merely restated the information provided in the problem without formulating a structured solution.

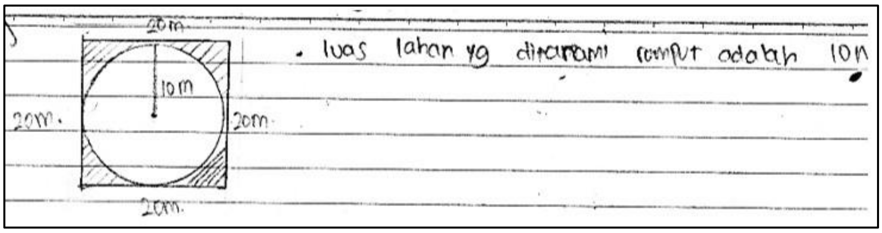

Figure 3. Response of the low-ability group (S-03) on the first task

Furthermore, in the second problem, differences in responses were also observed among the three groups. The response of the high-ability group to the second problem is presented in Figure 4.

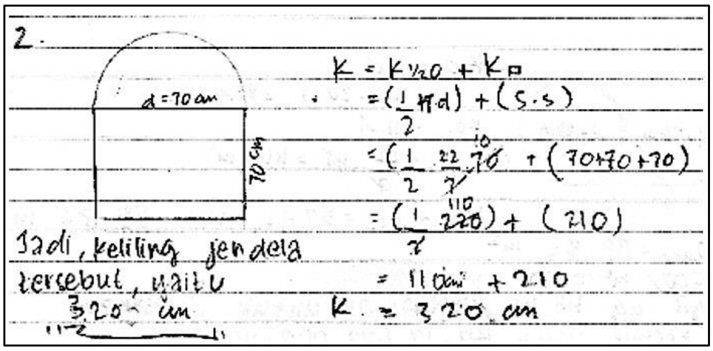

Figure 4. Response of the high-ability group (S-01) on the second task

Figure 4 illustrates that the student solved the second problem using a simultaneous problem-solving approach. After articulating the given mathematical situation, S-01 proceeded by formulating a mathematical model that integrated concepts of circles and squares. The response also demonstrates that students in this group consistently provided correct conclusions and properly included units. In contrast, students in the moderate-ability group consistently approached the second problem by solving each component separately, as shown in Figure 5.

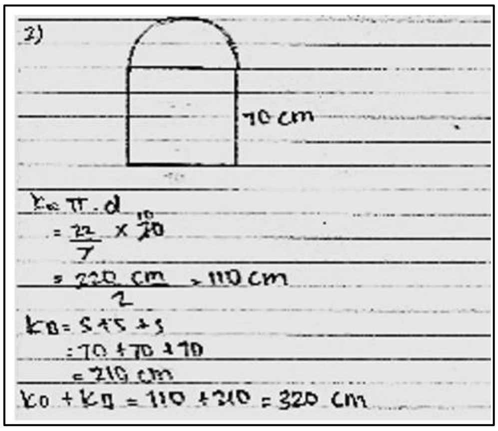

Figure 5. Response of the moderate-ability group (S-02) on the second task

Figure 5 shows that S-02 correctly solved the second problem. In addition to differences in problem-solving steps compared to the high-ability group, students in this group also consistently omitted a concluding statement in their responses. They considered their answer complete once they arrived at a numerical solution. Meanwhile, students in the low-ability group exhibited several limitations in their problem-solving process. An example of their response to the second problem is presented in Figure 6.

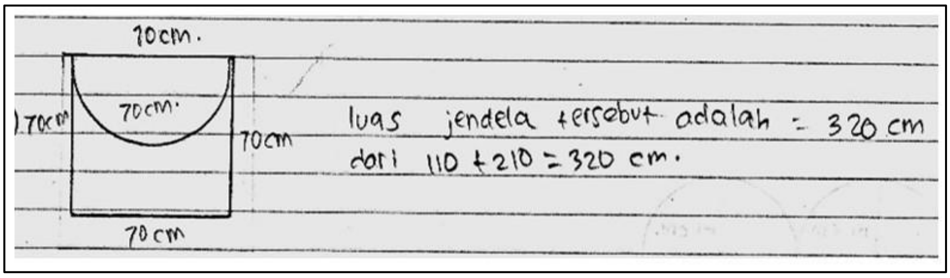

Figure 6. Response of the low-ability group (S-03) on the second task

Figure 6 shows that student S-03 from the low-ability group illustrated a diagram different from those of the other two groups. The student depicted the position of the semicircle as overlapping with the square. Additionally, S-03 did not outline the problem-solving steps, arriving at the values 110 and 210 without clarification. The response did not specify which value represented the perimeter of the semicircle or the perimeter of the square. These values were then summed to obtain 320 cm as the total perimeter of the given figure. The lack of detailed problem-solving steps indicates significant limitations in understanding and determining an appropriate solution strategy for the given problem.

These findings indicate that most students demonstrated moderate mathematical communication skills, while a smaller group exhibited low proficiency. The high number of students in the “moderate” category suggests that while most students have a basic understanding of mathematical communication, there is still room for improvement. Factors such as limited access to educational resources, exposure to mathematical communication practices, and the socio-economic challenges in the agricultural region likely influenced these results (Bahrun & Dasari, 2023; Rahman & Wandini, 2024). Conversely, the three students in the low category struggled to express and articulate mathematical concepts clearly, highlighting areas where additional support could enhance their skills.

An analysis of mathematical communication characteristics based on ability levels reveals distinct differences. High-ability students demonstrated proficiency across all three indicators, effectively translating word problems into mathematical models and integrating symbols, equations, and diagrams to represent given situations. Their simultaneous approach to problem-solving suggests conceptual fluency, defined as the ability to apply mathematical concepts flexibly and appropriately across various contexts (Samawati & Ekawati, 2021; Sanjaya et al., 2018). These students also provided comprehensive explanations, justifying each step of their solutions and demonstrating fluency in reasoning and deduction. This finding aligns with previous studies indicating that high-achieving students exhibit conceptual thinking and can offer well-structured explanations (Zahri et al., 2021). Furthermore, their ability to formulate relevant questions reflects their higher-order thinking skills, a trait commonly associated with strong mathematical literacy.

In contrast, moderate-ability students demonstrated partial proficiency in mathematical communication. While they could formulate mathematical models, their explanations often lacked clarity and depth. For instance, many of their written responses contained incomplete explanations or vague justifications for each step, resulting in less coherent solutions. A distinguishing characteristic of these students was their sequential approach to problem-solving, in which they addressed each component independently rather than integrating multiple representations. This finding suggests a reliance on procedural fluency—the ability to follow step-by-step procedures to solve problems—rather than conceptual understanding (Sanjaya et al., 2018; Utami et al., 2020). Furthermore, their inconsistent use of mathematical notation and units points to gaps in formal communication skills, a challenge commonly observed among students still developing symbolic literacy (Azizah et al., 2020; Pahmi & Prabawati, 2024). The absence of explicit conclusions in their responses also suggests that moderate-ability students may not fully recognize the importance of summarizing their reasoning, which is a crucial element of effective mathematical communication (Wandari & Anggara, 2021).

For low-ability students, mathematical communication presented significant challenges, particularly in constructing mathematical models. These students struggled to construct mathematical models, often resorting to restating problem information rather than formulating structured solutions. This finding is consistent with previous research indicating that low-ability students frequently repeat problem statements without developing a solution strategy (Perbowo et al., 2020; Wandari & Anggara, 2021). This inability to create clear mathematical representations and justifications suggests that these students struggle with problem-solving strategies and conceptual understanding. Furthermore, they struggled to interpret mathematical ideas and apply them to problem-solving tasks, requiring considerable effort to develop these skills (Saidah & Mardiani, 2021). Their difficulty transitioning between verbal, graphical, and symbolic representations further highlights their limited ability to communicate mathematical ideas in diverse forms. This challenge aligns with prior studies that indicate weak mathematical communicators often lack exposure to structured discussions and explicit reasoning exercises, which are essential for building both conceptual understanding and communication skills (Khairunnisa et al., 2020; Rohid et al., 2019; Samawati & Ekawati, 2021).

The observed differences in mathematical communication skills across the three proficiency levels highlight the critical role of cognitive and instructional factors in shaping students' abilities. Cognitive factors, such as prior knowledge, reasoning skills, and individual learning differences, significantly influence how students process and express mathematical ideas. This aligns with the findings of Prabawanto (2019) and Argarini et al. (2020), who emphasized the impact of these cognitive factors on students' mathematical communication skills. Instructional factors, including the quality of teaching, the availability of learning resources, and the teaching methods employed by instructors, also play a crucial role in developing these skills. This finding is supported by Prabawanto (2019) and Chasanah et al. (2020), who found that effective teaching practices are essential for enhancing students' ability to communicate mathematically. High-ability students could flexibly internalize and apply mathematical concepts, while moderate-ability students tended to rely more on procedural approaches. In contrast, low-ability students faced significant challenges, particularly in initiating problem-solving processes, likely due to gaps in their foundational knowledge and limited exposure to structured problem-solving strategies (Samawati

& Ekawati, 2021; Sanjaya et al., 2018). These findings suggest that improving students' mathematical communication skills requires a multifaceted approach that addresses cognitive development and instructional support (Argarini et al., 2020).

Written mathematical communication was another important factor influencing students' proficiency levels. Previous research indicates that students who regularly explain and justify their reasoning in writing tend to develop stronger problem-solving skills (Nurdiansyah & Ismail, 2020). Encouraging students to engage in written reflection—such as maintaining mathematical journals or participating in peer discussions—could significantly improve their ability to communicate mathematical reasoning clearly and effectively (Calkins et al., 2020; Yanti & Novitasari, 2021). Such practices could allow students to clarify and refine their understanding of mathematical concepts, enhancing their communication and problem-solving abilities.

Furthermore, the agricultural context of the study's setting is an essential factor to consider. Students in agricultural regions often engage in real-world quantitative tasks, such as calculating crop yields or measuring land areas. However, this practical experience does not necessarily translate into proficiency in formal mathematical communication (Fatimah et al., 2020). While students may be familiar with solving everyday problems, they may struggle to apply these skills within formal mathematical frameworks that require abstract reasoning and symbolic representation (Pahmi & Prabawati, 2024). Bridging the gap between students' everyday experiences and formal mathematical communication is critical in ensuring students can effectively apply their knowledge in academic settings.

In light of these findings, different learning strategies are needed to improve students' mathematical communication skills at different proficiency levels and accommodate students' different needs. The instructional activities for high-ability students should encourage higher-order thinking, such as constructing mathematical arguments and evaluating alternative solutions (Calkins et al., 2020). Moderate-ability students would benefit from structured problem-solving sessions and targeted feedback on their written explanations (Samawati & Ekawati, 2021; Sanjaya et al., 2018). For low-ability students, step-by-step guidance, visual aids, and work examples could provide the necessary support to strengthen their foundational communication skills (Nikmah & Nugraheni, 2023; Sanjaya et al., 2018). Additionally, fostering metacognitive awareness of mathematical communication—encouraging students to reflect on their reasoning, identify errors, and justify their solutions—can significantly enhance their critical thinking and communication abilities (Siregar, 2018). Incorporating formative assessments, such as mathematical journaling and peer discussions, can reinforce the importance of clarity and coherence in mathematical communication (Pahmi & Prabawati, 2024).

CONCLUSIONS

This study comprehensively analyzes students' mathematical communication skills in an agricultural-based region, revealing notable variations in proficiency levels. The findings indicate that most students demonstrate moderate mathematical communication abilities, with a smaller proportion exhibiting high proficiency. High-ability students effectively integrate mathematical models, symbols, and reasoning in their problem-solving processes. In contrast, moderate-ability students adopt a more procedural approach, occasionally making errors in notation and explanations. In contrast, low-ability students struggle with fundamental aspects of mathematical communication, often merely restating problem information without constructing organized solutions. These results highlight the significant influence of environmental factors, such as limited access to quality education and teaching methods, on students' development of mathematical communication skills. Additionally, while students in agricultural communities regularly engage with mathematical concepts in practical contexts, translating these experiences into formal mathematical communication remains a challenge.

The study underscores the importance of implementing targeted instructional strategies to enhance mathematical communication across various ability levels. High-ability students would benefit from tasks that encourage higher-order thinking and the construction of mathematical arguments. In contrast, moderate-ability students require structured discussions and detailed feedback to strengthen their reasoning skills. For low-ability students, step-by-step guidance, visual aids, and context-based examples could help build foundational communication competencies. Furthermore, instruction must be tailored to students' contextual knowledge, integrating real-world and culturally relevant problem-solving tasks, especially in rural and agricultural contexts.

However, this study has limitations, including its focus on a single region and the relatively small sample size, which may limit the generalizability of the findings. Other factors, such as students' socio-economic backgrounds, teaching methods, and potential limitations of the research instrument, may have also influenced the results. Future research should address these limitations by exploring a wider range of geographic contexts, including urban and suburban areas, to improve the generalizability of the findings. Larger sample sizes should also be considered to enhance statistical power and ensure the robustness of the conclusions. Moreover, investigating the long-term effects of specific instructional interventions on mathematical communication skills could provide valuable insights. Further studies could also explore how variations in socio-economic status and teaching methods influence students' communication abilities. Finally, integrating culturally relevant and real-world problem-solving approaches could further improve students' ability to articulate mathematical ideas effectively, particularly in agricultural and rural communities, where practical experiences are essential to their learning.

REFERENCES

Anisa, Y., Fahruza, R., & Hafiz, M. (2023). Students' mathematical communication skills in mathematics learning. *International Journal of Innovative Research in Computer Science and Technology*, *11*(6), 39–43. https://doi.org/10.55524/ijircst.2023.11.6.7

Argarini, D. F., Yazidah, N. I., & Kurniawati, A. (2020). The construction learning media and level of students' mathematical communication ability. *Infinity Journal*, *9*(1), 1–14. https://doi.org/10.22460/infinity.v9i1.p1-14

Azizah, N., Usodo, B., & Saputro, D. R. S. (2020). The written mathematical communication ability of junior high school students in solving set problems. *Journal of Physics: Conference Series*, *1538*(1). https://doi.org/10.1088/1742-6596/1538/1/012103

Bahrun, R. K. W., & Dasari, D. (2023). A literature review of indonesian students' mathematical communication ability in geometry materials. *EduLine: Journal of Education and Learning Innovation*, *3*(3), 354–358. https://doi.org/10.35877/454ri.eduline1880

Beding, B. T. (2017). Understanding the essence of phenomonoly and ethnography as the models of qualitative research on the basis of natural context: A literacy study. *Educational Research*, *08*(01), 9–12. https://doi.org/10.14303/er.2016.143

Beery, T. A. (2010). Essentials on qualitative research methods: Clinical considerations for allied professionals. *Heart Rhythm*, *7*(4), 572–574. https://doi.org/10.1016/j.hrthm.2009.12.001

Calkins, S., Grannan, S., & Siefken, J. (2020). Using peer-assisted reflection in math to foster critical thinking and communication skills. *PRIMUS*, *30*(4), 475–499. https://doi.org/10.1080/10511970.2019.1608608

Chasanah, C., Riyadi, & Usodo, B. (2020). The effectiveness of learning models on written mathematical communication skills viewed from students' cognitive styles. *European Journal of Educational Research*, *9*(3), 979–994. https://doi.org/10.12973/EU-JER.9.3.979

Dossett, J., Stripling, C. T., Haynes, J. C., Stephens, C. A., & Boyer, C. (2019). Mathematics efficacy and professional development needs of tennessee agricultural education teachers. *Journal of Agricultural Education*, *60*(4), 255–271. https://doi.org/10.5032/jae.2019.04255

Fatimah, A. T., Wahyudin, W., & Prabawanto, S. (2020). The role of agricultural contextual knowledge on the mathematical understanding of vocational students. *Journal of Physics: Conference Series*, *1521*(3). https://doi.org/10.1088/1742-6596/1521/3/032020

Firdaus, H. P. E. (2016). Analysis of mathematical communication skills students in mathematics education at study course junior high school mathematics. *International Conference on Education (IECO) Proceeding*, *1*(1), 344–351. https://core.ac.uk/download/pdf/229218213.pdf

Ikram, F. Z., & Rosidah, R. (2020). Rural vs urban: Teachers' obstacles and strategies in mathematics learning during COVID-19 pandemic. *Southeast Asian Mathematics Education Journal*, *10*(2), 69–74. https://doi.org/10.46517/seamej.v10i2.107

Ismayanti, S., & Sofyan, D. (2021). Kemampuan komunikasi matematis siswa SMP kelas VIII di kampung Cigulawing. *Plusminus: Jurnal Pendidikan Matematika*, *1*(1), 183–196. https://doi.org/10.31980/plusminus.v1i1.889

Khadijah, I. N. A., Maya, R., & Setiawan, W. (2018). Analisis kemampuan komunikasi matematis siswa SMP pada materi statistika. *JPMI Jurnal Pembelajaran Matematika Inovatif*, *1*(6), 1095–1104. https://doi.org/10.22460/jpmi.v1i6.p1095-1104

Khairunnisa, G. F., Maulyda, M. A., Annizar, A. M., Hijriani, L., & Khair, M. S. (2020). Mathematics communication: translation of elementary students' idea. *Numerical: Jurnal Matematika dan Pendidikan Matematika*, *4*(2), 77–86. https://doi.org/10.25217/numerical.v4i2.781

Lutfianannisak, L., & Sholihah, U. (2018). Kemampuan komunikasi matematis siswa dalam menyelesaikan soal materi komposisi fungsi ditinjau dari kemampuan matematika. *Jurnal Tadris Matematika*, *1*(1), 1–8. https://doi.org/10.21274/jtm.2018.1.1.1-8

Maulyda, M. A., Annizar, A. M., Hidayati, V. R., & Mukhlis, M. (2020). Analysis of students' verbal and written mathematical communication error in solving word problem. *Journal of Physics: Conference Series*, *1538*(1). https://doi.org/10.1088/1742-6596/1538/1/012083

Miles, M. B., Huberman, A. M., & Saldana, J. (2014). *Qualitative data analysis a methods sourcebook edition 3*. SAGE Publications, Inc.

NCTM. (2000). *Principles and standards for school mathematics*. Reston, Va.: The National Council of Teachers of Mathematics, Inc.

Nikmah, N., & Nugraheni, L. (2023). Analysis of students' mathematical communication skills in eight grade of junior high school on number patterns. *Journal of Education and Learning Mathematics Research (JELMaR)*, *4*(1), 20–30. https://doi.org/10.37303/jelmar.v4i1.106

Nurdiansyah, N. W., & Ismail, I. (2020). Profil komunikasi matematika tulis siswa SMP dalam memecahkan masalah matematika ditinjau dari kemampuan matematika siswa. *MATHEdunesa Jurnal Ilmiah Pendidikan Matematika*, *9*(2), 442–454. https://doi.org/10.26740/mathedunesa.v9n2.p442-454

OECD. (2023). *PISA 2022 results (Volume I): The state of learning and equity in education*. OECD. https://doi.org/10.1787/53f23881-en

Pahmi, M., & Prabawati, M. N. (2024). Analysis of students' mathematical communication skills through culturally responsive teaching and differentiated learning based on local wisdom. *Jurnal Inovasi Pendidikan dan Sains*, *5*(3), 142–147. https://doi.org/10.51673/jips.v5i3.2335

Palinussa, A. L., Molle, J. S., & Gaspersz, M. (2021). Realistic mathematics education: mathematical reasoning and communication skills in rural contexts. *International Journal of Evaluation and Research in Education*, *10*(2), 522–534. https://doi.org/10.11591/ijere.v10i2.20640

Perbowo, K. S., Hadi, W., & Haryati, T. (2020). Profile of mathematical communication skill viewed with problem-solving skill: A case of secondary students. *Sigma*, *5*(2), 65–69. https://doi.org/10.36513/sigma.v5i2.647

Prabawanto, S. (2019). Enhancement of students' mathematical communication under metacognitive scaffolding approach. *Infinity Journal*, *8*(2), 117–128. https://doi.org/10.22460/infinity.v8i2.p117-128

Puspa, S., Riyadi, R., & Subanti, S. (2019). Profile of mathematical communication skills junior high school students in problem solving. *Journal of Physics: Conference Series*, *1157*(3). https://doi.org/10.1088/1742-6596/1157/3/032125

Rahman, F. S., & Wandini, R. R. (2024). Pentingnya meningkatkan pengaruh kemampuan komunikasi matematis dan faktor yang mempengaruhi kemampuan komunikasi matematis siswa. *Journal Innovation In Education*, *2*(1), 37–46. https://doi.org/10.59841/inoved.v2i1.733

Rohid, N., Suryaman, S., & Rusmawati, R. D. (2019). Students' mathematical communication skills (MCS) in solving mathematics problems: a case in Indonesian context. *Anatolian Journal of Education*, *4*(2), 19–30. https://doi.org/10.29333/aje.2019.423a

Saidah, S., & Mardiani, D. (2021). Kesulitan siswa SMP terhadap soal komunikasi matematis pada materi penyajian data. *Plusminus: Jurnal Pendidikan Matematika*, *1*(3), 531–540. https://doi.org/10.31980/plusminus.v1i3.960

Samawati, I., & Ekawati, R. (2021). Students' mathematical communication skills in solving story problems based on mathematical abilities. *IJIET (International Journal of Indonesian Education and Teaching)*, *5*(1), 61–70. https://doi.org/10.24071/ijiet.v5i1.2730

Sanjani, A. R., Salido, A., Nasrum, A., Chairuddin, C., Jahring, J., & Sari, D. U. (2024). Exploring grade 8 students' procedural skills in solving pythagorean problems. *EduMa: Mathematics Education Learning and Teaching*, *13*(2), 165–182. https://doi.org/10.24235/eduma.v13i2.18719

Sanjaya, A., Johar, R., Ikhsan, M., & Khairi, L. (2018). Students' thinking process in solving mathematical problems based on the levels of mathematical ability. *Journal of Physics: Conference Series*, *1088*. https://doi.org/10.1088/1742-6596/1088/1/012116

Sugandi, A. I., & Bernard, M. (2018). Penerapan pendekatan kontekstual terhadap kemampuan pemahaman dan komunikasi matematis siswa SMP. *Jurnal Analisa*, *4*(1), 16–23. https://doi.org/10.15575/ja.v4i1.2364

Sutopo, L. A., & Waluya, S. B. (2023). Systematic literature review: kemampuan komunikasi matematis siswa ditinjau dari gaya berpikir. *Jurnal Pendidikan Matematika*, *1*(2), 1–15. https://doi.org/10.47134/ppm.v1i2.164

Umar, W. (2012). Membangun kemampuan komunikasi matematis dalam pembelajaran matematika. *Infinity Journal*, *1*(1), 1–9 https://doi.org/10.22460/infinity.v1i1.p1-9

Utami, L. F., Pramudya, I., & Slamet, I. (2020). Students' mathematical communication skills in terms of concrete and abstract sequential thinking styles. *Al-Jabar: Jurnal Pendidikan Matematika*, *11*(2), 371–381. https://doi.org/10.24042/ajpm.v11i2.7486

Wandari, W., & Anggara, B. (2021). Analysis of students difficulties in completing mathematical communication problems. *Journal of Physics: Conference Series*, *1918*(4). https://doi.org/10.1088/1742-6596/1918/4/042090

Whannell, R., & Tobias, S. (2015). Educating Australian high school students in relation to the digital future of agriculture. *Journal of Economic and Social Policy*, *17*(2), 61–80. https://search.informit.org/doi/10.3316/ielapa.279554598202506

Yanti, A. W., & Novitasari, N. A. (2021). Penggunaan jurnal reflektif pada pembelajaran matematika untuk melatih kemampuan komunikasi matematis siswa. *Mosharafa: Jurnal Pendidikan Matematika*, *10*(2), 321–332. https://doi.org/10.31980/mosharafa.v10i2.891

Zahri, M., Budayasa, I. K., & Lukito, A. (2021). Analysis of students' mathematical communication ability in solving mathematical problems. *Journal for the Education of Gifted Young Scientists*, *9*(3), 277–282. https://doi.org/10.17478/jegys.819995

Zulhelmi, Z., & Anwar, A. (2021). Mathematical communication skills in solving block and cube problems. *Journal of Physics: Conference Series*, *1882*(1). https://doi.org/10.1088/1742-6596/1882/1/012065