Jurnal Inovasi Pendidikan dan Sains
Vol. 5 No.3, Desember 2024: 142-147 ISSN 2721-9119 (Online)

ANALYSIS OF STUDENTS' MATHEMATICAL COMMUNICATION SKILLS THROUGH CULTURALLY RESPONSIVE TEACHING AND DIFFERENTIATED LEARNING BASED ON LOCAL WISDOM

Miptahul Pahmi [1*], Mega Nur Prabawati [2]

[1]Program Studi Magister Pendidikan Matematika, Universitas Siliwangi Tasikmalaya.
[2] Universitas Siliwangi, Tasikmalaya

*Email: miptahulpahmi29@guru.sma.belajar.id

Accepted: October 12th 2024. Approved: December 20th 2024. Published: December 29th 2024

Abstract: This study aims to analyze students' mathematical communication skills in solving problems related to measures of central tendency in real-life contexts, focusing on the aspects of drawing, mathematical expression, and written text, as well as types of Newman's errors. The analysis involved 25 students, with three selected as representatives based on their mathematical communication skill levels. The findings indicate that, on average, students exhibited a low level of errors across the three aspects, with average scores of 7.5 for drawing, 8.0 for mathematical expression, and 8.5 for written text. In the drawing aspect, students were able to present solutions visually well, although minor inaccuracies were noted. In the mathematical expression aspect, students understood the problems but tended to omit explicit solution steps. For the written text aspect, students often provided numerical results without formulating conclusions in sentence form. The main factors causing errors were a lack of habit in writing solution steps and conclusions, as well as a need for improved accuracy. A differentiated learning approach based on local wisdom positively contributed to reducing student error rates. However, strengthening practice in writing solution steps and composing conclusions is necessary to improve students' overall mathematical communication.

Keywords: mathematical, skills, culturally, local wisdom

INTRODUCTION

Mathematics is a critical discipline in education, as it not only involves calculations but also nurtures logical and analytical thinking skills. One of the essential skills in learning mathematics is students' mathematical communication ability, which refers to the capacity to convey mathematical ideas and solutions clearly, systematically, and structurally. This ability reflects mastery of mathematical concepts and procedures as well as their application in broader contexts. According to the National Council of Teachers of Mathematics [1], mathematical communication encompasses constructing arguments, explaining concepts, and exchanging ideas among students when solving problems.

Despite its importance, mathematical communication often poses challenges for many students, particularly in articulating complex mathematical concepts. Research by [2], [3] reveals that students' mathematical communication skills remain limited, hindering their ability to organize and express mathematical thoughts. Therefore, it is crucial to develop learning approaches that focus not only on content mastery but also on enhancing students' mathematical communication abilities.

One approach that can stimulate students' mathematical communication skills is through Critical Thinking (CRT). According to [4], critical thinking is the ability to analyze, evaluate, and make decisions based on logical reasoning and available information. In the context of mathematics education, this approach encourages students to engage deeply in the thought process, solve mathematical problems, and communicate their solution steps in a structured and logical manner. [5] further asserts that critical thinking can enhance students' problem-solving abilities, which, in turn, improves their mathematical communication skills.

In addition to critical thinking, the implementation of Culturally Responsive Teaching (CRT) is also vital in enhancing students' mathematical communication. In this context, students are not only required to understand mathematical concepts but also to communicate these ideas in a language and context they comprehend. [6] highlights that integrating local culture into learning creates a familiar context for students, making it easier for them to communicate mathematical ideas.

For example, in certain communities, traditional measurement systems are commonly used in daily life, such as in agricultural traditions. These measurement systems can be connected to mathematical concepts like measurement, geometry, or differentiation. By linking mathematical concepts to their real-life experiences, students find it easier to understand and communicate mathematical ideas using familiar language and symbols.

Differentiation is one of the mathematical topics often perceived as challenging by students, particularly in calculus, which involves understanding the change of one variable with respect to another. To address this difficulty, applying critical thinking and Culturally Responsive Teaching approaches can enhance students' mathematical communication skills in understanding and explaining differentiation processes. These approaches allow students to comprehend mathematical concepts in a more structured and relevant manner to their lives.

Furthermore [7] defines differentiation as adjusting instructional materials, processes, products, and environments to meet the diverse needs of students, considering their learning styles, interests, and ability levels. In this context, the implementation of CRT, which values students' cultural diversity, becomes essential. [8] adds that applying CRT in mathematics instruction creates a more inclusive space where students feel valued and motivated to participate actively. By integrating students' local culture into the curriculum, abstract mathematical concepts such as differentiation become more accessible. For instance, in learning differentiation, students familiar with traditional agricultural measurements may find it easier to grasp the concept of change through practical applications, such as growth rates of crops or changes in soil temperature over time.

This study aims to analyze how the application of Culturally Responsive Teaching (CRT) can enhance students' mathematical communication skills, particularly in learning differentiation. The study focuses on how students articulate and present their mathematical thought processes clearly and systematically and how a differentiated approach supported by CRT principles can improve the quality of students' mathematical communication.

By analyzing students' responses, this research seeks to provide new insights into effective ways to optimize mathematics instruction. Additionally, the findings are expected to contribute to the development of teaching methods that are more responsive to the diverse needs of students and capable of enhancing their mathematical communication skills.

RESEARCH METHODS

This study is a descriptive research with a qualitative approach aimed at describing students' mathematical communication skills after being taught using differentiated process learning based on local wisdom in the topic of measures of central tendency. The research was conducted at SMAN 2 Banjarsari, Ciamis Regency, involving 25 students, and was carried out during the odd semester of the 2024/2025 academic year. A test was used to collect data on the mathematical communication skills of SMAN 2 Banjarsari students. The study focused on class XII IPS-3, with research subjects selected purposively. Students chosen for interviews were selected to provide accurate information regarding their mathematical communication skills.

The research data were analyzed descriptively to illustrate the conditions related to the subjects, including the difficulties faced by students during the learning process using a differentiated process approach integrated with Culturally Responsive Teaching (CRT). The evaluation of student responses considered errors made, challenges encountered, strengths demonstrated, and the fulfillment of mathematical communication skill indicators.

The analysis of students' worksheets focused on their mathematical communication skills as described by three indicators: (1) **Written text**: representing ideas or solutions to problems through written descriptions, including diagrams or graphs, using their own words; (2) **Drawing**: depicting ideas or solutions to problems using diagrams, graphs, tables, or mathematical terms; and (3) **Mathematical expression**: expressing real-life problems or events using mathematical models or statements.

Student responses were analyzed based on Newman's Error Analysis [9] Newman’s steps were selected to identify the types of errors students made and the factors contributing to these errors when solving mathematical story problems

.

RESULTS AND DISCUSSION

The researcher analyzed the responses of 25 students on geometry problems related to real-life situations, where several difficulties faced by the students were identified. To analyze the students' response processes, three students were selected, ensuring that their answer sheets represented the aspects of mathematical communication skills, namely drawing, mathematical expression, written text, and the types of Newman’s errors, including misconceptions, transformation errors, process skill errors, and answer writing errors. A description of the frequency of each type of error in each question is presented in Table 1.

Table 1. Error Results Based on Mathematical Communication Aspects

Aspek	N	Min	Max	Sum	(Rata-rata)	Std. Deviation
Drawing	25	4	11	187.5	7.5	2.03
Mathematical Expression	25	6	10	200.0	8.0	1.22
Written Text	25	5	12	212.5	8.5	2.03
Data Keseluruhan	25	4	12	600.0	8.0	1.89

Based on Table 1, the average results of the students' mathematical communication skills test are as follows: (1) The **drawing aspect**, based on the process skill error indicator, scored 7.5, which is categorized as a low error rate; (2) The **mathematical expression aspect**, based on the transformation error and misconception indicators, scored 8.0, which is also categorized as a low error rate; and (3) The **written text aspect**, based on the answer writing error indicator, scored 8.0, indicating a low error rate as well.

Drawing Aspect – Process Skill Error Indicator

The analysis shows that, in the **drawing aspect** under the process skill error indicator, students no longer make mistakes in finding the correct solution to geometry problems, with a score of 7.5, indicating a high level of performance in the differentiated process learning approach with CRT based on local wisdom. This suggests that students no longer make errors in transforming mathematical results from symbols into sentences that match the problem, in identifying what is being asked in the problem, or in writing the conclusion correctly. Figure 2 shows some mistakes still made by students.

From the student's worksheet (SS-1), SS-1 wrote what was being asked in the problem. Here's an excerpt from SS-1's answer sheet.

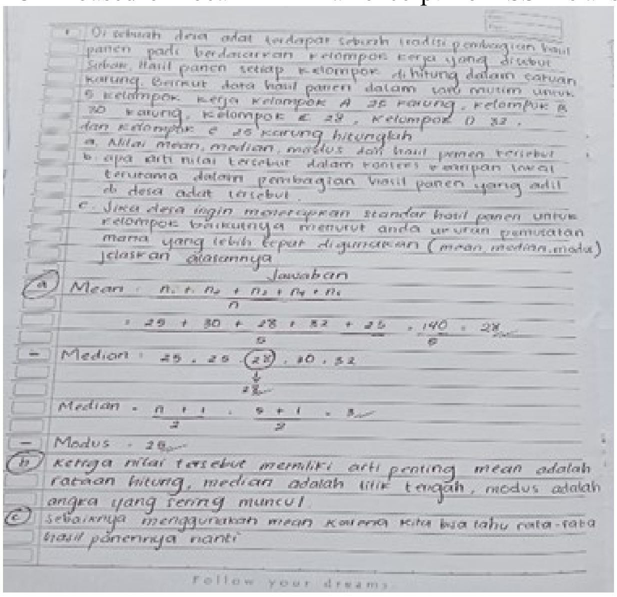

Figure 1. SS-1's Answer

Figure 1 shows that SS-1 answered correctly and precisely and was able to illustrate and answer the first point correctly. However, for the next point, the student made a mistake due to lack of attention when solving the word problem.

Mathematical Expression Aspect – Transformation and Misconception Error Indicators

From the analysis of the error level in the differentiated process learning approach with CRT based on local wisdom for solving the mathematics problems related to the topic of measures of central tendency, the **mathematical expression aspect** showed a score of 8.0 for transformation and misconception error indicators, indicating a high level of no errors. Therefore, it can be stated that students understood the problem, translated real-life situations into mathematical symbols, avoided errors in selecting the correct mathematical steps, and fulfilled the communication skills aspect and error analysis indicators. Below is an excerpt from AF-2's answer sheet.

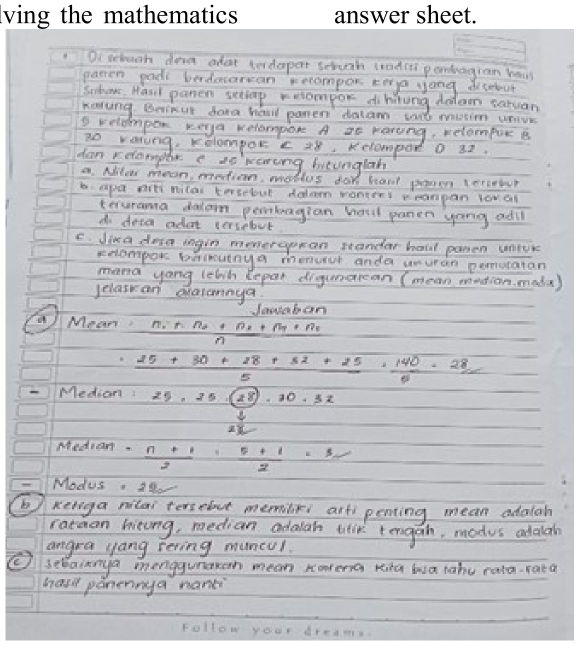

Figure 2. AF-2's Answer

Figure 2 shows that AF-2 answered correctly and precisely, being able to compute the solution accurately, but did not fully illustrate the problem in the formula. This indicates that AF-2 was able to solve the problem but still made a mistake in not fully following the required steps.

Written Text Aspect – Answer Writing Errors

The students' worksheets showed that many students were able to complete the problems related to measures of central tendency using the differentiated process learning approach with CRT based on local wisdom. The error rate in writing results was 8.5, which is categorized as high. Based on the analysis, most students no longer made errors in writing results, but some still made mistakes such as: misinterpreting the final results according to the problem, misclassifying what the problem meant to reach the correct result, and errors in drawing conclusions. Figure 3 shows the student's worksheet.

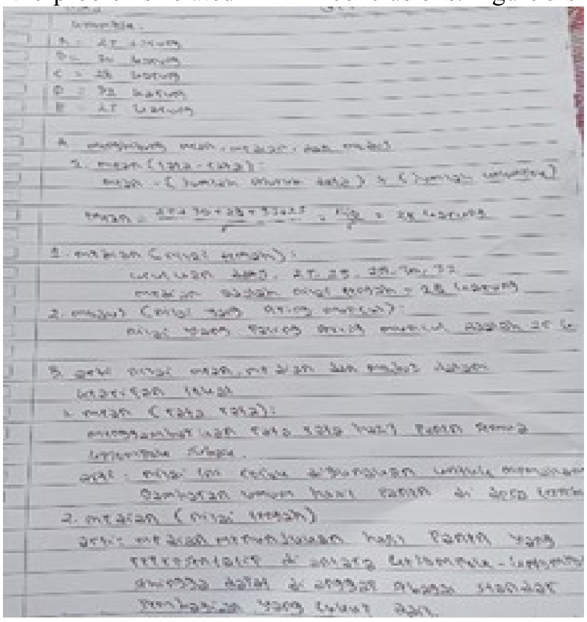

Figure 3. AM-3's Answer

Based on this analysis, SS-1, AF-2, and AM-3 did not face difficulties in making conjectures, constructing arguments, formulating definitions, and generalizing to solve the problem.

The analysis of students' answers indicates that their mathematical communication skills in various aspects, such as drawing, mathematical expression, and written text, fall into the category of "minimal errors."

In the **drawing** aspect, students were able to accurately illustrate solutions, with an average score of 7.5. This demonstrates that students have successfully translated mathematical symbols into visual representations relevant to the problem. However, some students still showed a lack of precision, as seen in the case of student SS-1, who, despite providing correct answers in several parts, made minor errors due to inaccuracy when solving word problems. The differentiated learning process using a CRT (Culturally Responsive Teaching) approach based on local wisdom played an essential role in helping students develop these skills.

In the **mathematical expression** aspect, students' errors in transforming and understanding problems were also minimal, with an average score of 8.0. Most students could interpret word problems into relevant mathematical symbols. However, challenges were observed in students like AF-2, who understood the elements of the problem but chose not to write them down, considering it time-consuming. This indicates that while students comprehend mathematical concepts well, there is a need to emphasize the habit of explicitly outlining and articulating steps in the learning process.

In the **written text** aspect, students demonstrated relatively good performance in solving word problems, with an average score of 8.5. However, some weaknesses persisted in writing complete conclusions. For instance, student AM-3 tended to stop at presenting numerical results without summarizing conclusions in sentences that explicitly addressed the problem. This issue stems from students' lack of understanding of the importance of conclusions and their habitual approach to stopping at that stage. Factors contributing to these errors include a lack of precision in converting numbers into sentences and insufficient practice in writing explicit conclusions.

Overall, although students SS-1, AF-2, and AM-3 were able to understand and solve problems, there are areas that need improvement, particularly in consistently providing complete answers. A learning process that emphasizes the importance of articulating steps and drawing conclusions can help students become more precise and accustomed to solving problems with better mathematical communication. The local wisdom-based learning approach provides a solid foundation but needs to be complemented with more intensive practice to enhance students' precision and understanding of mathematical communication.

Based on the analysis of students' answers, it can be concluded that students' mathematical communication skills in the aspects of drawing, mathematical expression, and written text generally fall into the category of "minimal errors." Students demonstrated good abilities in illustrating solutions, translating real-world problems into mathematical symbols, and correctly solving word problems. However, certain weaknesses need attention, such as precision in symbolization and writing complete conclusions.

Some students, such as SS-1, AF-2, and AM-3, although capable of understanding and solving problems correctly, tend to overlook important details, such as explicitly stating solution steps or providing conclusions in sentences that align with the problem. This indicates that learning with a CRT (Culturally Responsive Teaching) approach based on local wisdom has yielded positive results. However, further efforts are needed to encourage students to develop habits of providing complete and structured answers, especially in word problems that involve mathematical communication aspects.

CONCLUSION

Based on the analysis of students' answers, it can be concluded that students' mathematical communication skills in the aspects of drawing, mathematical expression, and written text generally fall into the category of "minimal errors." Students demonstrated good abilities in illustrating solutions, translating real-world problems into mathematical symbols, and correctly solving word problems. However, certain weaknesses need attention, such as precision in symbolization and writing complete conclusions.

Some students, such as SS-1, AF-2, and AM-3, although capable of understanding and solving problems correctly, tend to overlook important details, such as explicitly stating solution steps or providing conclusions in sentences that align with the problem. This indicates that learning with a CRT (Culturally Responsive Teaching) approach based on local wisdom has yielded positive results. However, further efforts are needed to encourage students to develop habits of providing complete and structured answers, especially in word problems that involve mathematical communication aspects.

REFERENCES

[1] National Council of Teachers of Mathematics (NCTM). (2018). *Principles and standards for school mathematics*. Reston, VA: NCTM.

[2] Dewi, M. W. K., & Nuraeni, R. (2022). *Kemampuan Komunikasi Matematis Siswa SMP ditinjau dari Self-Efficacy pada Materi Perbandingan di Desa Karangpawitan*. Plusminus: Jurnal Pendidikan Matematika, 2(1), 151–164. https://doi.org/10.31980/plusminus.v2i1.1586

[3] Bernard, M., Nurmala, N., Mariam, S., & Rustyani, N. (2018). *Analisis Kemampuan Pemecahan Masalah Matematis Siswa SMP Kelas IX Pada Materi Bangun Datar*. SJME (Supremum Journal of Mathematics Education), 2(2), 77–83. https://doi.org/10.35706/sjme.v2i2.1317

[4] Facione, P. A. (2018). *Critical thinking: What it is and why it counts*. Insight Assessment.

[5] Ennis, R. H. (2018). *Critical thinking: A streamlined conception*. Prentice-Hall.

[6] Dewi, M. W. K., & Nuraeni, R. (2022). Kemampuan Komunikasi Matematis Siswa SMP ditinjau dari Self-Efficacy pada Materi Perbandingan di Desa Karangpawitan. Plusminus: Jurnal Pendidikan Matematika, 2(1), 151–164. https://doi.org/10.31980/plusminus.v2i1.1586

[7] Tomlinson, C. A. (2019). *The differentiated classroom: Responding to the needs of all learners*. ASCD.

[8] Ladson-Billings, G. (2018). *The dreamkeepers: Successful teachers of African American children*. Jossey-Bass.

[9] Hadiyanto, F. R. (2020). *Analisis Kesalahan Siswa Kelas VII dalam Menyelesaikan Soal Geometri. Transformasi* : Jurnal Pendidikan Matematika Dan Matematika, 2(1), 21–31. https://doi.org/10.36526/tr.v5i2.1310

[10] Ardan, S. M. A. (2020). *Analisis Kemampuan Komunikasi MAtematis Siswa dalam Menyelesaikan Soal Persamaan Garis Lurus Kelas VIII SMP Negeri 1 Sungguminasa Kabupaten Gowa Berdasarkan Tingkat IQ* [Universitas Muhammadiyah Makassar]. https://digilibadmin.unismuh.ac.id/upload/18170-Full_Text.pdf

[11] Dewi, R. A. (2017). *Integrating local cultural values in mathematics learning to enhance students' conceptual understanding*. Bandung: Alfabeta.

[12] Kuslinar, K., Awaludin, A., & La Arapu, L. A. (2019). *Pengaruh Model Pembelajaran Kooperatif Tipe Think Talk Write (Ttw) Terhadap Kemampuan Komunikasi Matematis Siswa Kelas Viii Smp Negeri 1 Sampara*. Jurnal Penelitian Pendidikan Matematika, 7(1), 141. https://doi.org/10.36709/jppm.v7i1.8255

[13] Purwandari, A. S., Astuti, M. D., & Yuliani, A. (2018). *Evaluasi Kemampuan Komunikasi Matematis Siswa SMP Pada Materi Sistem Persamaan Linear Dua Variabel*. Indomath: Indomanesian Mathematics Education, 1(1), 55–62. https://doi.org/10.33387/dpi.v10i1.2785

[14] Rahmayani, S. R., & Effendi, K. N. S. (2019). *Kemampuan Komunikasi Matematis Siswa SMP Pada Materi Himpunan*. Judika (Jurnal Pendidikan Unsika), 7(1), 10–18. http://journal.unsika.ac.id/index.php/judika

[15] Sugiyono. (2018). *Metode penelitian pendidikan: Pendekatan kuantitatif & kualitatif*. Bandung: Alfabeta.

[16] Wijaya, H. P. I., Sujadi, I., & Riyadi. (2016). *Kemampuan Komunikasi Matematis Siswa Sesuai dengan Gender dalam Pemecahan Masalah Pada Materi Balok dan Kubus (Studi Kasus Pada Siswa SMP Kelas VIII SMP Islam Al-Azhar 29 Semarang)*. Jurnal Elektronik Pembelajaran Matematika, 4(9), 778–788. https://jurnal.fkip.uns.ac.id/index.php/s2math/article/view/9654

[17] Zaditania, A. P., & Ruli, R. M. (2022). *Kemampuan Komunikasi Matematis Siswa SMP dalam Menyelesaikan Soal Himpunan*. Jurnal Educatio FKIP UNMA, 8(1), 328–336. https://doi.org/10.31949/educatio.v8i1.1997