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Analysis of Mathematical Communication Ability of High School Students on the Circle Material

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Abstract
This study analyzed high school students' mathematical communication skills on circle problems based on three categories: high, medium, and low. The research method used was qualitative with a descriptive approach. Data were collected through written tests and interviews to determine students' understanding and how they communicated their thinking processes in solving circle problems. The results showed that students with high ability were able to answer correctly and explain systematically. Students in the medium category understood most of the concepts but were less coherent in their explanations. Meanwhile, students in the low category had difficulty understanding the concepts and explaining their answers. These findings emphasize the importance of mathematical communication in mathematics learning. Therefore, it is recommended that learning emphasize discussion and the delivery of ideas to improve student understanding.
Keywords: *Mathematical Communication, Circles, Student Analysis, Mathematics Learning.*

Abstrak
Penelitian ini menganalisis kemampuan komunikasi matematis siswa sekolah menengah atas pada materi lingkaran berdasarkan tiga kategori: tinggi, sedang, dan rendah. Metode penelitian yang digunakan adalah kualitatif dengan pendekatan deskriptif. Data dikumpulkan melalui tes tertulis dan wawancara untuk mengetahui pemahaman siswa serta bagaimana mereka mengomunikasikan proses berpikirnya dalam menyelesaikan soal lingkaran. Hasil penelitian menunjukkan bahwa siswa dengan kemampuan tinggi mampu menjawab dengan benar dan menjelaskan secara sistematis. Siswa pada kategori sedang memahami sebagian besar konsep, namun kurang koheren dalam memberikan penjelasan. Sementara itu, siswa pada kategori rendah mengalami kesulitan dalam memahami konsep dan menjelaskan jawabannya. Temuan ini menegaskan pentingnya komunikasi matematis dalam pembelajaran matematika. Oleh karena itu, pembelajaran disarankan untuk lebih menekankan diskusi dan penyampaian ide guna meningkatkan pemahaman siswa.
Kata Kunci: Komunikasi Matematis, Lingkaran, Analisis Siswa, Pembelajaran Matematika

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INTRODUCTION

Mathematics is the study of the structure, patterns, and relationships between numbers, shapes, and other abstract concepts. The term "mathematics" comes from the Greek "mathematike," meaning "studied science" or "knowledge."(Rahmah, 2013). in the context of education, mathematics includes various branches such as arithmetic, algebra, geometry, and analysis(Sugiyamti, 2018). mathematics not only functions as a tool for calculating or solving numerical problems, but also as a symbolic language for expressing quantitative and spatial relationships.(Siagian, 2017)This makes mathematics the "queen of sciences" that underpins many other disciplines. Learning mathematics aims to develop students' logical, analytical, systematic, and creative thinking skills. (Hatip & Setiawan, 2021)The process involves active interaction between teachers, students, and learning resources, requiring students to understand mathematical concepts and principles in a structured and systematic manner.(Susilawati, 2020).

In addition to increasing knowledge, learning mathematics aims to build students' mathematical connection skills to understand patterns, regularities, and relationships between concepts.(Siagian, 2016)Mathematics learning in high school plays a crucial role in developing students' critical and logical thinking skills. However, many students struggle to grasp the concepts, leading to negative perceptions. According to the National Council of Teacher Mathematics (NCTM), the five core competencies in mathematical skills recommended by the National Council of Teacher Mathematics (NCTM) are problem-solving, communication, connection, reasoning, and representation.(Maryati et al., 2022).

Mathematics has a role as a symbolic language that enables accurate and precise communication.(Riswandha & Sumardi, 2020). Meanwhile, according to Shadiq, however, it is very unfortunate that the mathematics learning process that takes place in Indonesia is still mostly oriented towards mastering basic skills, with very little emphasis on applying mathematics in the context of everyday life, communicating mathematically, and reasoning mathematically.(Agustyaningrum & Widjajanti, 2013). Most students believe that mathematics is a difficult subject, this is because the lessons given by teachers are too boring, there is a lack of practice questions, and there is not enough communication between educators and students.(Fitriani & Hidayati, 2022).

According to Syarafina, CBL integrates various sources of information and previous experiences, so that students can be deeply involved in the learning process.(Safira et al., 2015)This approach encourages students to think critically and creatively, and improves their collaboration skills.(Asfar et al., 2019)Research shows that case-based learning can help students better understand complex mathematical concepts, as well as improve their analytical skills.(Nuraeni & Luritawaty, 2016)This study aims to determine how case-based learning strategies are applied to develop high school students' mathematical communication skills, as well as the effectiveness and challenges that arise in the process.

The solution in this research is that the application of case-based learning strategies can provide relevant and interesting contexts for students, thus encouraging them to be more active

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in communicating mathematically, both through group discussions and in explaining the steps for solving problems. This strategy is also expected to be able to help students with different academic abilities to understand mathematical concepts more deeply through contextual learning experiences. Based on the researcher's observations, there are several problems in the learning process in the classroom, namely: (1) students are less careful in reading and writing mathematical symbols; (2) students face difficulties in interpreting images or problems into mathematical models; and (3) there is a lack of student accuracy in understanding images or problems in the context of mathematical models.(Wulandari & Ekawati, 2023)However, the current reality in the field shows that students' mathematical communication skills are generally still relatively low.(Octviani & Noor Aini, 2022).

This results in students' communication being hampered, which has an impact on their difficulty in socializing and they tend to enjoy their own world more.(Amatul Wahid & Rina Marlina, 2022). Because communication with peers is not going well, learning solutions are needed that can improve students' communication skills. This problem relates to mathematical communication, both written and oral. Through communication, ideas can become objects of reflection that can be improved, discussed, and changed.(SanononiSarumaha et al., 2022). When students are challenged to communicate their thinking to others, both verbally and in writing, they learn to explain, persuade, and use mathematical language appropriately. Understanding this background, this study aims to explore more deeply students' mathematical communication skills on circles and the factors that influence them, thereby providing recommendations for developing more effective teaching methods.

METHODS

This research uses a qualitative approach because it aims to examine phenomena comprehensively using language and words, in a specific natural context, and presented descriptively.(Wulandari & Ekawati, 2023). The research subjects consisted of 36 students of class X1 D of a senior high school in the even semester of the 2024/2025 academic year, who had studied Circles. The subject selection criteria included students of the same gender and equivalent mathematical abilities. Furthermore, the selected subjects also had speaking or communicative abilities, so they could provide data on mathematical communication in both oral and written forms.

Mathematical communication skills are a crucial aspect of mathematics learning, particularly in understanding the concept of circles. Through mathematical communication, students can express their thoughts clearly, both verbally and in writing, and are able to connect learned concepts to real-world situations. In this study, we analyzed high school students' mathematical communication skills on circles, focusing on solving problems related to arc lengths and central angles.

To understand the variation in students' mathematical communication skills, interviews and analysis of responses were conducted across three categories: high, medium, and low. High-ability students were able to explain concepts coherently and used a variety of effective problem-solving strategies. Medium-ability students demonstrated a fairly good

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understanding but still struggled to confidently communicate their mathematical reasoning. Meanwhile, low-ability students tended to have difficulty understanding and explaining concepts, although they were able to complete calculations with guidance.

RESULT AND DISCUSSION

The results of this analysis provide insight into how each student category interacts with the concept of circles and how they express their mathematical understanding. Differences in how students answer and explain their solutions to problems indicate that mathematical communication is not just about obtaining the correct answer, but also involves the ability to interpret, explain, and connect concepts logically. The following section will further discuss the results of the analysis of student answers based on their mathematical communication ability categories.

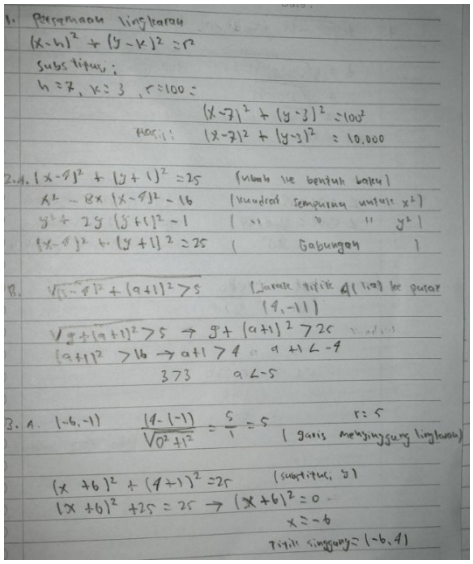

Figure 1. Results of Students' Answers in High Category

Students in this category demonstrate a strong understanding of the concept of circles, particularly in determining arc length based on the information provided. They are able to organize their answers systematically, explain each calculation step with clear reasoning, and use formulas correctly. In answering questions, students in the high category can relate the concept of central angles to the ratio of arc lengths and use it to quickly and accurately determine the length of arc BC. Furthermore, they can present their answers well both verbally and in writing, and can explain their concepts again when asked for further information.

Q : "Can you explain how to solve the problem of the length of arc BC?"

S1 : "Yes, ma'am, first I understand that the length of an arc is proportional to its central angle. Since the central angle AOC=140˚, I can calculate the central angle BOC by subtracting it from 360˚, the result is 220˚. Is that right, ma'am?"

Q : "Then, what are the next steps?"

S1 : "I use the ratio of the arc length to its central angle:

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$$\frac{\text{Panjang AB}}{\text{Panjang BC}} = \frac{140}{220}$$

Then I substitute AB=35 then I calculate the length of BC "$= \frac{35 \times 220}{140} = 55$

Q : "Is there any other way that can be used?"

S1 : "Yes, ma'am, you can also use the arc length formula directly, namely L, but because the question doesn't give the radius, the comparison method is faster."$= \frac{\theta}{360} \times 2\pi r$

Q : "Very good! You explained it very clearly and systematically."

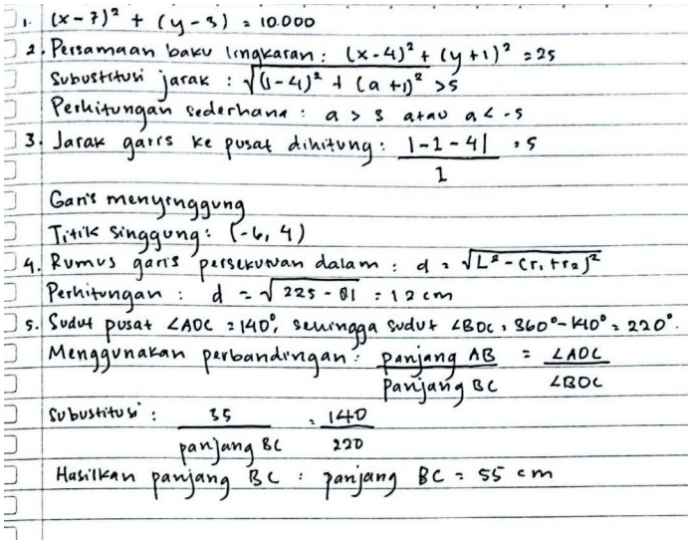

Figure 2. Results of Students' Answers in Moderate Category

Students in this category had a sufficient understanding of the concept of circles, but still struggled to structure and communicate their answers coherently. They were able to use the correct formula, but sometimes lacked precision in calculations or were unable to explain the reasoning behind their steps. During interviews, several students in this category were able to answer follow-up questions with the help of prompts from the researcher. Although their understanding was quite good, they still encountered several minor conceptual errors, indicating the need for further strengthening in their mathematical communication.

Q : "How do you solve the problem of the length of arc BC?"

S2 : "I know, Ma'am, that the total angle of a circle is 360°. Since angle AOC = 140°, then I calculate BOC by 360°−140° = 220°."

Q : "Then how do you calculate the length of arc BC?"

S2 : "I use the ratio between the central angle and the arc length. Since AB=35, then I use the ratio:

$$\frac{35}{\text{BC}} = \frac{140}{220}$$

I simplified the fraction and then calculated the length of BC, the result was 55 cm."

Q : "Can you explain the reasons why the comparative method can be used?"

S2 : "Your answer is quite good! You still need to be more confident in explaining the concept."

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Figure 3. Results of Students' Answers in Low Category

Students in the low category have difficulty understanding the concept of arc length and its relationship to the central angle. They tend to struggle to determine the correct formula and are less able to explain the steps they take. In some cases, students answer by trial and error without understanding the underlying concepts. When given guidance, they can solve problems with assistance, but still struggle to express their thought processes mathematically. Their answers are often poorly structured and lack sufficient explanation.

Q : "How do you solve the problem of the length of arc BC?

S3 : "I know that the total angle of a circle is 360˚, Ma'am. Since angle AOC = 140˚, then I calculate BOC by 360˚−140˚ = 220˚."

Q : "Then how do you calculate the length of arc BC?"

S3 : "I use the ratio between the central angle and the arc length. Since AB = 35

$$\frac{35}{BC}=\frac{140}{220}$$

I simplified the fraction, Ma'am, then calculated the length of BC, the result was 55 cm."

Q : "Can you explain the reasons why the comparative method can be used?"

S3 : "Hmm… because the length of the arc is proportional to its central angle. So if the angle is larger, the length of the arc is also longer, is that right, ma'am."

Q : Your answer is quite good! You still need to be more confident in explaining the concept.

CONCLUSION

Based on the research results, it can be concluded that high school students' mathematical communication skills in the circle topic vary according to their level of understanding. Students with high abilities are able to answer correctly, provide systematic explanations, and

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use mathematical concepts well. Students in the medium category understand most of the concepts but still lack the ability to construct coherent explanations. Meanwhile, students in the low category have difficulty understanding the circle concept and are less able to explain their answers clearly. These findings indicate that mathematical communication plays a crucial role in understanding geometric concepts, especially circles. Therefore, learning strategies that emphasize interaction, discussion, and the verbal and written delivery of ideas are needed so that students can improve their mathematical communication skills. In addition, teachers need to provide more intensive guidance to students who experience difficulties in understanding the material.

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