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Analysis of Students' Mathematical Literacy Skills on the Pythagorean Theorem in Junior High School

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ABSTRACT

Mathematical literacy can help students to find solutions to everyday life problems. This research uses descriptive qualitative research. The purpose of this study was to determine the description of mathematical literacy abilities and profiles of mathematical literacy abilities of eighth grade students of SMP Plus Ihyaul Ulum Muntilan. The data collection techniques used were written tests and in-depth interviews of 6 selected students. The material tested in the written test is the Pythagorean Theorem. The data analysis technique uses the theory of Miles and Huberman, namely data reduction, data presentation and conclusion drawing. Triangulation technique was used to test the validity of the data. The results of this research showed that the achievement of the communicating aspect is 45,54%, mathematising aspect is 99,10%, representation aspect is 67,85%, reasoning and argument is 51,78%, devising strategies for solving problems it is obtained 40,17%, using symbolic, formal and technical language and operations are only 3,57%, using mathematics tools is only 0,89%.

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1. Introduction

The analysis of eighth-grade students' mathematical literacy skills on the Pythagorean Theorem has become crucial in efforts to improve the quality of mathematics education in Indonesia. Mathematical literacy not only includes arithmetic skills but also the ability to understand, analyze, and apply mathematical concepts in everyday life (Harini et al., 2023). According to the OECD (2019), mathematical literacy refers to an individual's ability to formulate, apply, and interpret mathematics in various contexts, including real-world situations.

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Therefore, a deep understanding of mathematical literacy is essential in formal education, particularly in learning the Pythagorean Theorem, which has widespread applications across different fields.

A study conducted by Anisah & Nasrudin (2023) and Shandy et al. (2021) found that students with a visual learning style tend to successfully perform all stages of mathematical literacy, including formulating, applying, interpreting, and evaluating solutions. They find it easier to understand concepts with the aid of images or diagrams that clarify the relationships between the sides of a triangle in the Pythagorean Theorem. However, students with kinesthetic or auditory learning styles may encounter difficulties in some of these aspects, as they rely more on direct experiences or verbal explanations to comprehend the material (Miller, 2023). Therefore, more diverse teaching methods are needed to accommodate different learning styles.

Another study conducted by Yuliana & Suwito (2024) also revealed significant variations in students' mathematical literacy skills regarding the Pythagorean Theorem. While some students could present problems in mathematical form and select appropriate solution strategies, others struggled with these stages. This indicates that differences in academic backgrounds, understanding of basic concepts, and learning motivation influence students' mathematical literacy. Problem-based learning and group discussions can help students develop a deeper understanding of the concepts taught while enhancing their critical thinking skills (Septiany et al., 2024; Yogyanto et al., 2024).

On an international scale, the results of the Programmed for International Student Assessment (PISA) 2022 showed that Indonesia's ranking improved by 5–6 positions compared to 2018. However, despite this improvement in ranking, Indonesia's mathematical literacy score dropped by 13 points, from 379 in 2018 to 366 in 2022. This decline suggests that despite the rise in ranking, significant challenges remain in improving the quality of mathematics education. Factors such as conventional teaching methods, limited use of technology in learning, and students' low problem-solving skills are likely the main contributors to this decline (Caesaria et al., 2024; Pulungan et al., 2024).

This decline in mathematical literacy scores is not unique to Indonesia. The global average mathematical literacy score in PISA 2022 fell by 21 points compared to 2018. However, Indonesia's smaller decrease compared to the global average suggests that efforts to improve the quality of mathematics education in the country have begun to show results, although there is still much to improve (Indahsari & Kintoko, 2021; Siswanto, 2025). Several countries with more advanced education systems have also experienced similar downward trends, indicating that the COVID-19 pandemic, which disrupted learning processes, has had a global impact on students' academic achievements (Oktaviani et al., 2021).

Several factors influence students' mathematical literacy skills, including teaching methods, the availability of learning resources, and a supportive learning environment (Tambunan & Mahmudi, 2024; Tarso et al., 2025). Research conducted by Caesaria et al. (2024) suggests that the implementation of teaching models such as quantum teaching can enhance students' mathematical literacy skills. This model emphasizes active student engagement in the learning process with a more enjoyable and meaningful approach (Rohid et al., 2019). Additionally, active

student involvement in learning and the application of mathematical concepts in real-world contexts can help improve their understanding and skills. For example, the use of project-based learning or problem-based learning can help students connect mathematical concepts with real-life situations, enhancing their memory retention and conceptual understanding.

To improve students' mathematical literacy skills in the Pythagorean Theorem, SMP Plus Ihyaul Ulum Muntilan can implement various innovative teaching strategies tailored to students' needs. For instance, the use of interactive learning media, such as digital simulations or computer-based educational games, can help students grasp concepts more effectively. Additionally, implementing project-based learning, where students solve real-world problems involving the Pythagorean Theorem, can help improve their analytical and problem-solving skills (Pimdee et al., 2024). Providing contextual practice problems can also help students develop the ability to apply learned concepts in daily life (Apriwulan et al., 2025; Suryani et al., 2024).

Moreover, it is essential for schools to continuously monitor and evaluate students' mathematical literacy skills regularly. This can be done through diagnostic tests, classroom observations, and student interviews to gain a deeper understanding of the challenges they face in learning (Atta et al., 2023). By doing so, teachers can identify students' difficulties and provide appropriate interventions to address these issues. One approach that can be implemented is formative assessment, where teachers continuously evaluate students' understanding and adjust their teaching strategies based on the assessment results (Hanphitakphong & Poomsalood, 2024).

Overall, the analysis of eighth-grade students' mathematical literacy skills on the Pythagorean Theorem at SMP Plus Ihyaul Ulum Muntilan provides insights into the effectiveness of the mathematics learning process. By understanding the factors influencing students' mathematical literacy, schools can design more effective teaching strategies that cater to students' needs, ultimately improving the overall quality of mathematics education. Through the implementation of more innovative and student-centered teaching methods, it is hoped that students' mathematical literacy skills will significantly improve in the future. Consequently, enhancing mathematical literacy not only benefits students' academic understanding but also prepares them to face real-world challenges that require logical and analytical thinking skills.

2. Method

The research employed a qualitative approach with a descriptive method. This approach aims to illustrate the phenomena observed in the study (Sugiyono, 2019). The study was conducted to describe students' mathematical literacy skills in solving problems related to the Pythagorean Theorem. The analysis was carried out by reviewing students' responses based on mathematical literacy indicators, such as Communicating, Mathematising, Representation, Reasoning and Argument, Devising Strategies for Solving Problems, Using Symbolic, Formal and Technical Language and Operation, and Using Mathematics Tools. Data were collected by administering mathematical literacy tests to all eighth-grade students at SMP Plus Ihyaul Ulum Muntilan, consisting of 28 students (10 male and 18 female). Based on the test results, six students were selected for interviews, including two students

with high literacy skills, two with moderate literacy skills, and two with low literacy skills.

This research was conducted in the even semester of the 2023/2024 academic year, specifically in April 2024, at SMP Plus Ihyaul Ulum, located in Muntilan District, Magelang Regency, Central Java Province. To categorize students' abilities, a classification system based on average scores and standard deviation was used, following the criteria proposed by Arikunto (2017). The data analysis model applied in this study follows in models Miles & Huberman (1994), which includes data collection, data reduction, data presentation, and conclusion drawing.

3. Results and Discussion

Results

The results of the mathematical literacy test of grade VIII students of SMP Plus Ihyaul Ulum showed that 6 students had mathematical literacy skills in the high category, 17 students in the medium category, and 5 students in the low category. From these results, 6 students were selected, namely S-1 and S-2 in the high category, S-14 and S-15 in the medium category, S-26 and S-28 in the low category to be interviewed. The following are the results of the S-1 work.

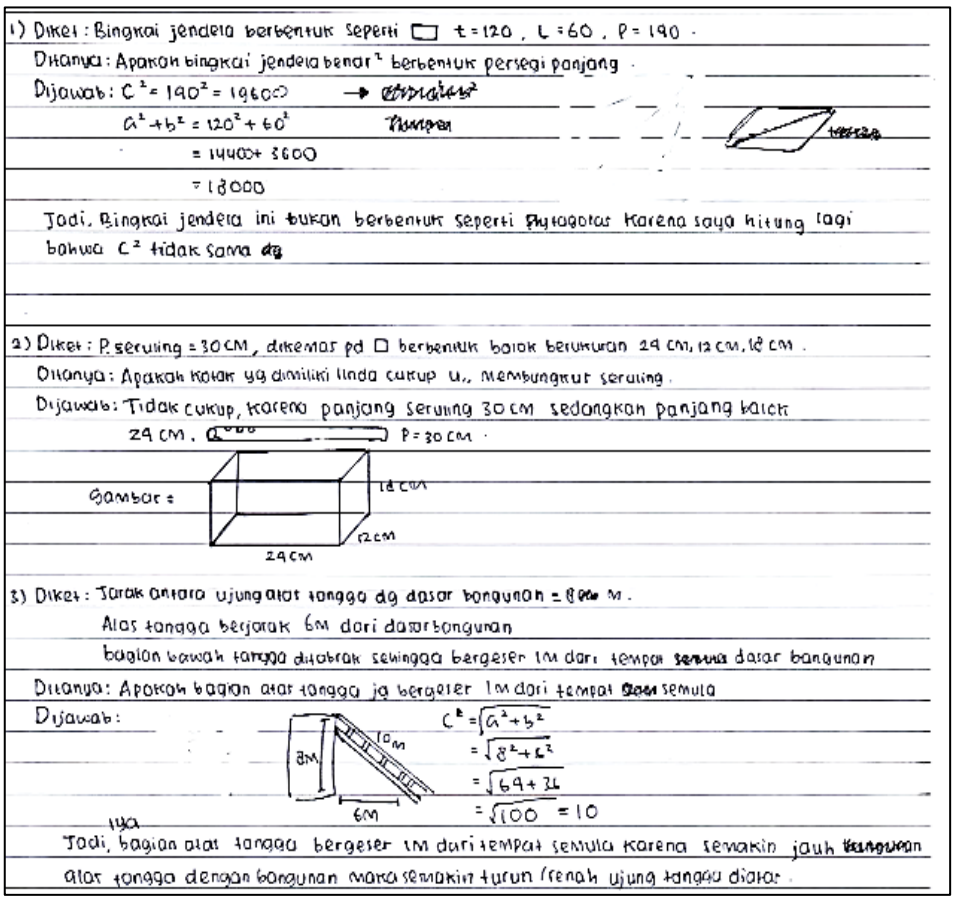

Figure 1. S-1 Work Results

Based on the image above, S-1 is a student who has high category mathematical literacy skills. This can be seen from S-1's work which meets the assessment criteria based on 7 components of mathematical literacy assessment. S-1's shortcomings in working on questions are only slightly incomplete. For example, when drawing, the image identity or image caption is not given. In general, S-1 has met the 7 assessment components except for the last component, namely using mathematics tools, although S-1's answer is not yet perfect. The following are the results of S-2 and S-3's work.

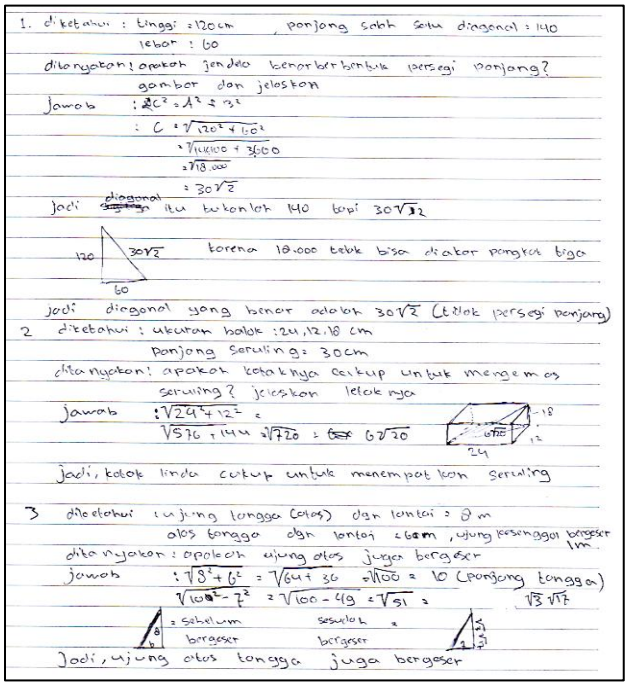

Figure 2. S-2 Work Results

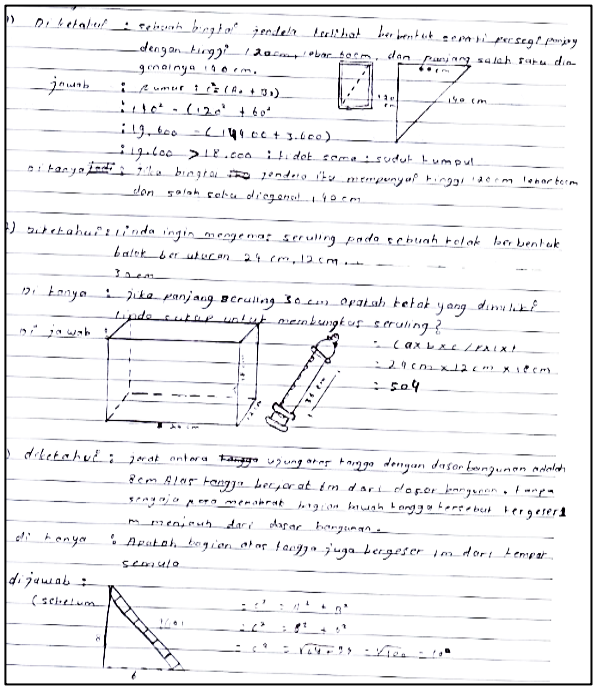

Figure 3. S-3 Work Results

Based on the illustration presented in the image above, students who are given the code S-2 are included in the category of students with a high level of mathematical literacy skills. In general, S-2 can fulfil five of the seven assessment components used as indicators in this study. This shows that S-2 has a good understanding of mathematical concepts and can apply various aspects of mathematical literacy in solving the problems given. Meanwhile, students with the code S-3 are categorized as students with a moderate level of mathematical literacy skills. In working on the problems, S-3 is also able to fulfil five of the seven assessment components that have been determined. However, even though they have fulfilled the five components, the answers given by S-3 are not completely correct or in accordance with the mathematical concepts that should be applied. This indicates that even though S-3 has a sufficient understanding of the concepts being tested, there are still some errors or mistakes in the problem-solving process.

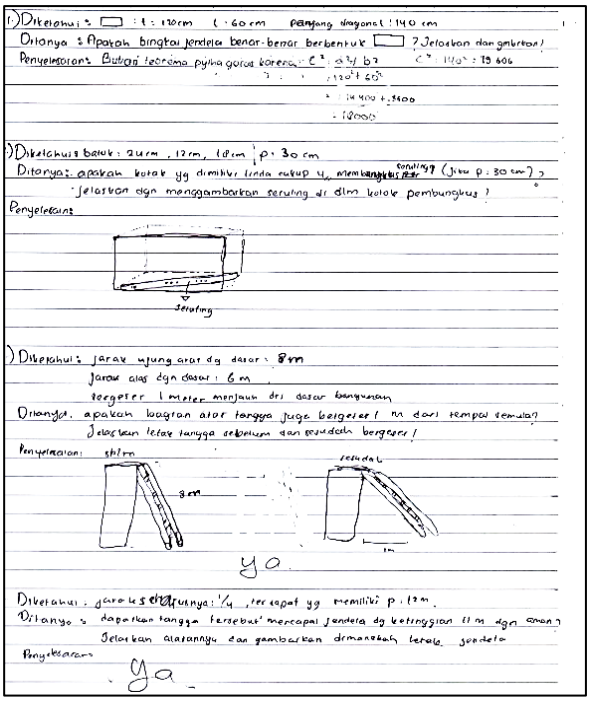

Figure 4. S-4 Work Results

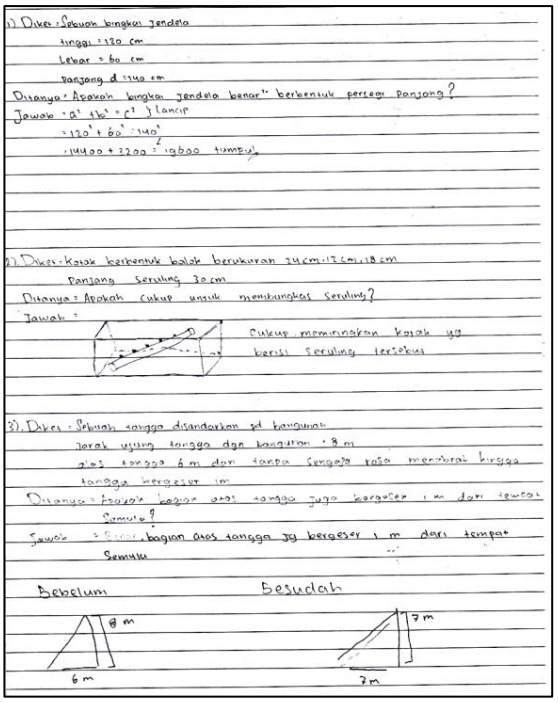

Figure 5. S-5 Work Results

Based on the image above, S-4 is a student with mathematical literacy skills in the medium category. S-4 can fulfill 4 assessment components, namely mathematics, reasoning and argument, devising strategies for solving problems, and using symbolic formal and technical language and operation. Meanwhile, S-5 is a student with low category mathematical literacy skills. S-5 is only able to fulfill 3 assessment components out of 7 assessment components, namely mathematics, Reasoning and Argument, and Devising strategies for solving problems. The following are the results of S-6's work.

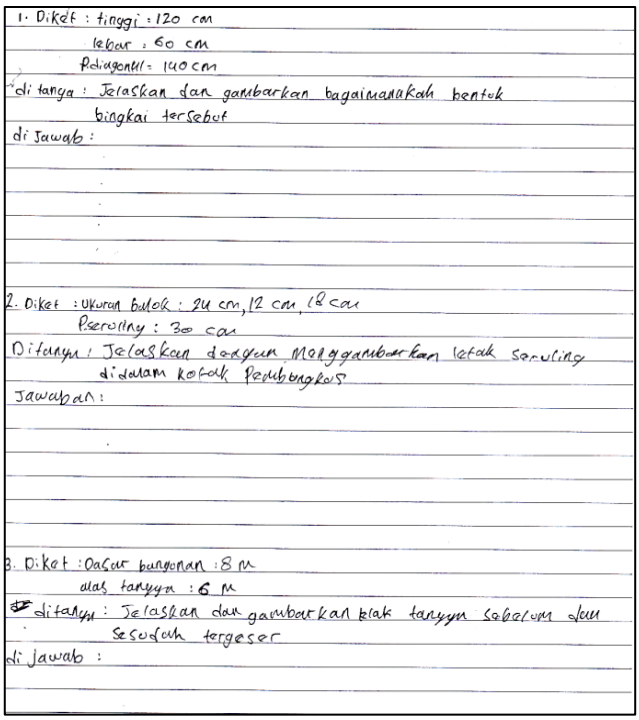

Figure 6. S-6 Work Results

Based on the picture above, S-6 is a student with low mathematical literacy skills. This can be seen from the limitations in solving the given problems, where students are only able to do mathematising, namely changing the problem into mathematical form, without being able to proceed to the next stage in solving the problem. S-6 is only able to write down the information known and asked in the problem without showing the right solution strategy or doing the necessary calculations. In addition, students are unable to connect the concepts that have been learned with the context of the questions given, so they cannot draw the right conclusions. Furthermore, achievements based on student literacy ability indicators can be seen in the following picture.

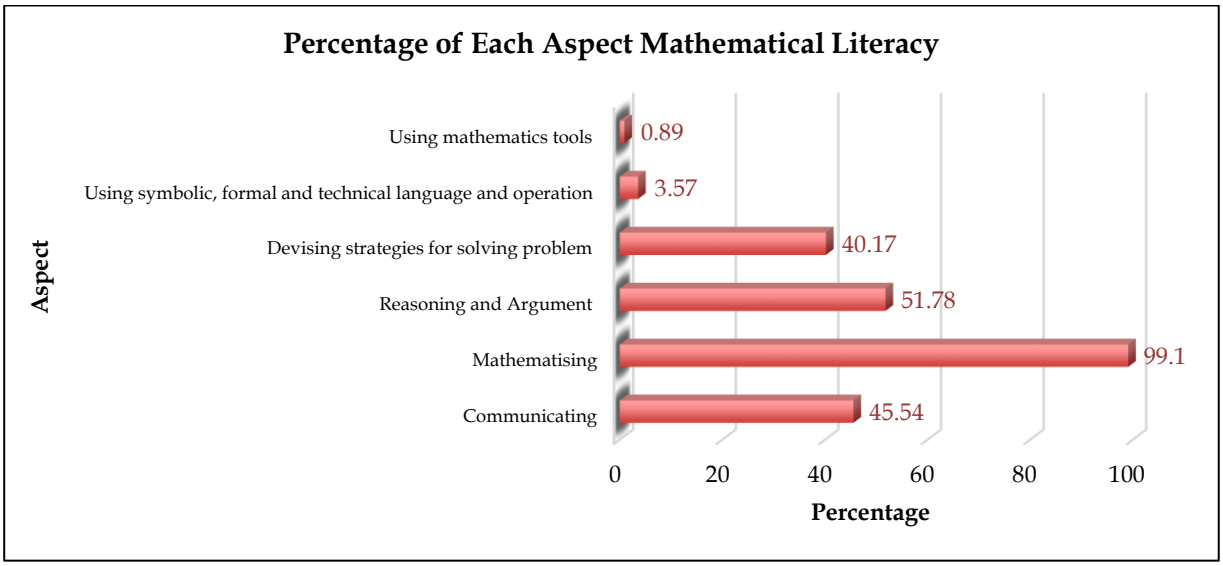

Figure 7. Percentage of Each Aspect of Mathematical Literacy

Based on the data presented, students' mathematical literacy skills in various indicators show quite significant variations. The mathematising indicator has the highest percentage, which is 99.1%, which shows that almost all students can identify and change real situations into mathematical models. Reasoning and argument skills are also quite good with an achievement of 51.78%, which means that more than half of students can provide reasons and arguments for solving mathematical problems. However, in the aspect of communicating, only 45.54% of students can communicate mathematical ideas and solutions clearly, indicating that there are still obstacles in explaining the concepts they have understood. Meanwhile, devising strategies for solving problems only reached 40.17%, which shows that students still have difficulty in designing effective problem-solving strategies. Even more worrying, in the indicator of the use of symbolic, formal, and technical language, only 3.57% of students can apply it well, and the use of mathematical tools is at the lowest figure, which is 0.89%, which reflects the lack of utilization of mathematical tools in the problem-solving process.

Discussion

The research findings on the mathematical literacy skills of eighth-grade students at SMP Plus Ihyaul Ulum reveal a significant variation in students' abilities. Out of a total of 28 students who participated in the mathematical literacy test, only 6 students (21.43%) were classified in the high category, while the

majority, comprising 17 students (60.71%), fell into the medium category, and 5 students (17.86%) were categorized as having low mathematical literacy. Interviews conducted with six students representing each category indicated that students with high mathematical literacy generally managed to meet nearly all components of mathematical literacy. In contrast, students in the medium and low categories tended to struggle with several aspects, particularly in using symbolic and formal language as well as mathematical tools. These findings align with Aprilia et al. (2025) and Masjudin et al. (2024), who found that many students across different countries, including Indonesia, still face challenges in fully comprehending and applying mathematical concepts, especially in mathematical communication and problem-solving aspects.

More specifically, students in the high category, such as S-1 and S-2, demonstrated the ability to fulfil almost all components of mathematical literacy, although some deficiencies were still observed in specific aspects, such as the use of mathematical tools. This suggests that students with high mathematical literacy tend to understand and apply mathematical concepts in various contexts but still require reinforcement in technical aspects. These findings are consistent with the study conducted by Kaushik et al. (2021), which emphasizes that although students with high mathematical literacy can construct arguments and employ effective problem-solving strategies, they still need guidance in using mathematical tools such as diagrams, tables, or mathematical software to support their problem-solving processes.

On the other hand, students in the medium category, such as S-3 and S-4, exhibited more limited abilities, particularly in the aspects of communicating and devising strategies for solving problems. This indicates that while these students can identify problems and engaging in reasoning, they still struggle to develop systematic problem-solving strategies and clearly communicate their mathematical ideas. These findings are reinforced by research conducted by Lutfi et al. (2024) and Wantoro et al. (2025), which states that many students in Indonesia continue to face difficulties in mathematical communication and problem-solving strategies due to a lack of practice in constructing systematic responses and limited experience in explicitly presenting mathematical arguments.

Meanwhile, students in the low category, such as S-5 and S-6, encountered more significant challenges in nearly all aspects of mathematical literacy. They were only able to meet a small portion of the mathematical literacy components, particularly at the initial stage, such as mathematising, but struggled to progress to more advanced stages, including reasoning, problem-solving strategies, and the use of mathematical language. These results are consistent with the findings of Apelo & Arcenas (2024), which indicate that students with low abilities often can only partially comprehend problems without being able to connect them to broader mathematical concepts. Furthermore, other factors, such as a lack of experience in solving contextual problems, also serve as major obstacles to improving their mathematical literacy skills.

Overall, the research findings highlight a significant gap in students' mathematical literacy abilities. The mathematising indicator, which has the highest percentage (99.1%), suggests that almost all students can translate real-life situations into mathematical models. However, other aspects, such as

communicating (45.54%), devising strategies for solving problems (40.17%), and the use of symbolic language and mathematical tools (3.57% and 0.89%, respectively), remain at a very low level. These findings reaffirm previous studies, such as the research conducted by Apelo & Arcenas (2024), which indicates that many Indonesian students still focus primarily on procedural aspects without fully understanding the underlying concepts. Therefore, there is a need for learning strategies that place greater emphasis on mathematical communication, the use of supporting tools, and problem-solving strategies to enhance students' mathematical literacy in a more comprehensive manner.

4. Conclusions

Based on the discussion above, it can be concluded that the achievement of the communicating aspect is 45.54%, the achievement of the mathematising aspect is 99.10%, the achievement of the representation aspect is 67.85%, the reasoning and argument aspect is 51.78%, the devising strategies for solving problems aspect is obtained 40.17%, the using symbolic, formal and technical language and operation aspect is only 3.57%, using mathematics tools is only 0.89%. The results of the study also showed that there were 6 students in the high category, 17 students in the medium category, and 5 students in the low category with a total of 28 students. Referring to the discussion in this study, the researcher suggests that further researchers conduct similar or more in-depth research considering the importance of students' mathematical literacy skills.

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