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# Analysis of Junior High School Teachers' Mathematical Literacy Skills In Solving High Order Thinking Skills (HOTS) Problems

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***ABSTRACT***

*This research is a descriptive qualitative research that aims to describe the mathematical literacy skills of junior high school mathematics teachers in solving HOTS problems. Research subject selection is based on the teachers' work period consisting of four teachers, such as two junior teachers and two senior teachers. The research instruments are HOTS problems at level 5 and level 6, and interview guidelines. The results of the research showed that in solving HOTS problem at level 5, there were junior and senior teachers who were only able to fulfill 3 of the 6 mathematical literacy indicators. In solving HOTS problem at level 6, there was junior teacher who had not fulfilled one of the mathematical literacy indicators well and there was senior teacher who could only able to fulfill just one of the mathematical literacy indicators. However, other junior and senior teachers were able to fulfill the overall mathematical literacy indicators. Hence, there are still both junior and senior teachers who have not been able to solve HOTS problems well, so they have not been able to fulfill the overall mathematical literacy indicators.*

***Keywords***: *Junior High School Teacher, Mathematical Literacy Skills, Higher Order Thinking Skills (HOTS) Problems*

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## INTRODUCTION

Programme of International Student Assessment (PISA) is one of the programs participated in by Indonesia since 2000 to assess three basic competencies, that is Mathematics, Science, and Reading. The mathematical problems presented in PISA are real problems that require reasoning skills, spatial skills, or problem solving skills (OECD, 2018). This problem is a problem that can be used to measure high-level thinking skills which are often referred to as Higher Order Thinking Skills (HOTS) (Dinni, 2018; Widana, 2017).

The achievement of Indonesian students in PISA from 2000 to 2018 was quite sad. The results of the PISA International study of Indonesian students showed that the achievements of reading literacy, mathematics literacy, and science literacy achieved by Indonesian students were very low (Mayari et al., 2022; Widana, 2017). Thus, it is necessary to re-examine the deficiencies that need to be fixed so that in the next PISA period the average mathematics score can increase significantly and Indonesia will no longer be at the bottom of the rankings. Empirical facts in the field show that mathematics textbooks for junior high school level are also starting to be equipped with HOTS problems, but most teachers do not discuss HOTS problems in the textbooks and are often only made as homework without further discussion. This shows that many teachers do not choose these problems to be taught to their students.

Abdullah, et al. (2017) and Genc & Erbas (2019) assume that every teacher needs in-depth knowledge and skills to assess their students' high level thinking skills. In order to have the skills to assess high level thinking skills, teachers should have a good level of mathematical literacy so that they can design learning strategies that can train students' high level thinking skills and create assessment tools to assess their students' high level thinking skills (Untu et al., 2023). Mahdiansyah & Rahmawati (2014) also added that teachers play a very important role in students' mathematical literacy skills, especially in high level thinking (High Order Thinking).

Teachers' mathematical literacy skills are teachers' abilities to formulate, use, and interpret mathematics in various contexts of everyday life problems efficiently, especially those related to problems that give rise to high level thinking problems (Umbara & Suryadi, 2019). Teachers who have fairly good literacy skills according to the PISA mathematical literacy level in solving HOTS problems are expected to easily train HOTS problems to their students in order to explore students' high level thinking skills. Sulastri, et al (2014) stated that PISA levels are classified into three parts based on the level of difficulty in the completion process. The first level is easy consisting of problems at level 1 and 2, the second level is moderate difficult consisting of problems at level 3 and 4, while the third level is most difficult consisting of problems at level 5 and 6.

Teacher's work period in education, especially in teaching has a positive correlation with the competencies that teachers are required to have (Siregar et al., 2021; Syamsumarlin et al., 2021). In the regulation of the Minister of State Apparatus Empowerment Number 16 of 2009, there are two groups of teachers with the middle teacher and junior teacher groups based on their teaching experience. Junior teachers are teachers

with the position level of first-class superintendent and group III-D with a maximum teaching experience of eight years. While middle teachers are teachers with the position level of administrator and group IV-A with a minimum of eight years of teaching. Given the delineation of these two categories of educators, the researcher in this study employs the terminology of junior teacher and senior teacher.

Some studies that are relevant to this research are research by Indah, et al. (2016) which discusses improving the mathematical literacy skills of junior high school students through the application of the Problem Based Learning (PBL) learning model. The results of the study stated that the initial mathematical literacy skills of junior high school students were still very low, which was indicated by the students' inability to solve problems in the form of formulating, applying, and even interpreting mathematics into various contexts. However, there was an increase in mathematical literacy skills after the PBL learning model was applied. Further research by Suyitno (2013) which discusses the development of mathematics teachers' abilities in compiling mathematical literacy problems through a scientific approach. These two studies have differences with the research conducted by the researchers. If the research by the researchers assess the mathematical literacy skills of teachers in solving HOTS problems as seen from the teacher's work period, it does not assess students' mathematical abilities or develop teachers' abilities in compiling mathematical literacy problems. And there has been no research that discusses the research conducted by the researchers.

Thus, the researchers decided to conduct a research entitled "Analysis of Junior High School Teachers' Mathematical Literacy Skills in Solving High Order Thinking Skills (HOTS) Problems". This research aims to describe the mathematical literacy skills of junior and senior mathematics teachers in junior high school level in solving HOTS problems. Furthermore, it is hoped that the results of this research can be used as reflection material and reference material to improve planning starting from teaching strategies to the formation of evaluation tools to determine studets' high level thinking skills.

## METHOD

This investigation employs a qualitative methodology and adopts a descriptive research design. The study was carried out among mathematics educators at the junior high school tier, as it aligns with the objectives of the mathematical literacy assessment, which specifically targets students at the junior high school level.

Research subject selection is based on the teachers' work period consisting of four teachers from four different schools, namely two junior teachers and two senior teachers. The selection of the four subjects is for comparison between the mathematical literacy of junior teachers and senior teachers in solving problems. The sampling method used is purposive sampling. Criteria considered in selecting subjects are: (1) subjects with teachers' work period in accordance with the provisions for junior teachers (maximum work period of 8 years) and senior teachers (minimum work period of 8 years), and (2) subjects have good oral and written communication skills so that they can express optimally what they are thinking when solving the problems.

The research instrument used in this study was HOTS problems at level

5 and 6, and interview guidelines to reveal the mathematical literacy skills of junior and senior teachers in junior high school level. The HOTS problems used are the results of development research by Gustiningsi & Somakim (2021) and Putra, et al. (2016) which have passed the validity and practicality tests. The data analysis technique used is Miles, et al. (2014) model which consists of: (1) data condensation stage, (2) data display stage, and (3) conclusion drawing/verification stage. The results of mathematical literacy test were analyzed based on the mathematical process used in PISA which is stated in the mathematical literacy indicators adapted from the OECD (2019) in Table 1 below.

Table 1. Mathematical Literacy Indicators

| Mathematical Process | Indicators | Code |
|---|---|---|
| *Formulate* | • Identify the mathematical aspects of a given problem | F1 |
| | • Translate the problem into approriate mathematical language | F2 |
| *Employ* | • Design and use problem solving strategies to obtain right solutions to given problems | E1 |
| | • Perform right calculations to produce right solutions to problems | E2 |
| | • Apply right concepts, facts, and algorithms in determining solutions to given problems | E3 |
| *Interpret* | • Interpret the solutions discovery to given problems | I1 |
| | • Evaluate the suitability of the solution to the given problems | I2 |

The conclusion is drawn through the activity of digging up detailed information from the answer sheets of HOTS problems and interviews. Furthermore, the credibility and validity of the data are tested using the method triangulation by comparing the results of working on HOTS problems with the results of the interviews.

This research used four research subjects, namely two junior teachers with J1 and J2 codes, and two senior teachers with S1 dan S2 codes. The answers of the research subjects to each HOTS problem given and the results of the interview will be analyzed based on the mathematical literacy indicators in Table 1. Figure 1 below is the answer of junior teacher 1 (J1) to HOTS problems at level 5 and level 6.

## RESULTS AND DISCUSSION

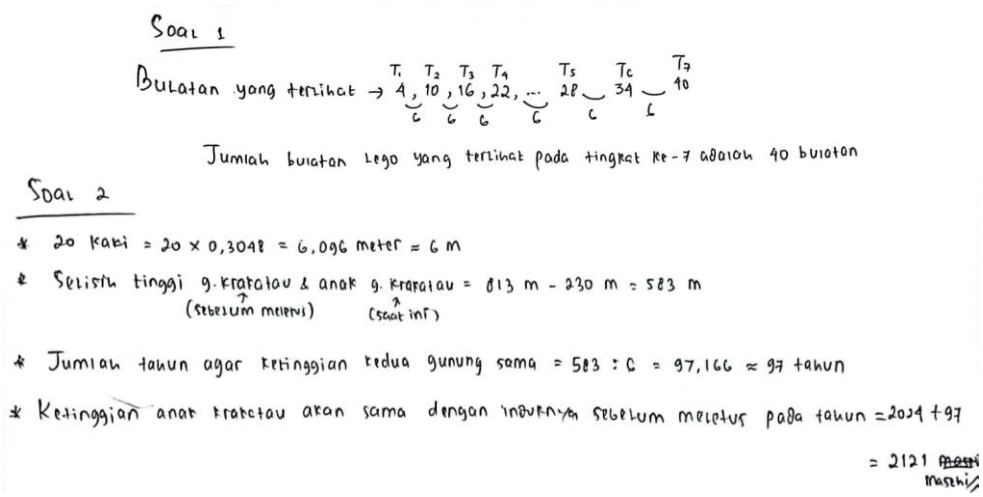


Figure 1. Answer of J1 for HOTS Problems at Level 5 (Problem 1) and Level 6 (Problem 2)

The results of the J1 answer sheets and interviews were analyzed based on the mathematical literacy indicators. Table 2 below explains the achievement of J1's mathematical literacy skills based on the mathematical literacy indicators.

Table 2. Achievement of J1's mathematical literacy skills based on mathematical literacy indicators

| Code | HOTS problem at Level 5 | HOTS problem at Level 6 |
|---|---|---|
| F1 | J1 was able to mention the information known in the problem, namely the number of visible lego circles at the first level, which is four circles. | J1 was able to mention the information known in the problem, such as the year Mount Krakatau erupted, the additional height of Mount Anak Krakatau every year, the current height of Mount Anak Krakatau, and the height of Mount Krakatau before it erupted. |
| F2 | J1 symbolized the number of visible circles at each lego level with symbol $T_n$ where $n$ is the order of the level from the top. | J1 wrote the information presented in the problem directly, without changing the problem into mathematical language. |
| E1 | J1 showed a problem-solving strategy according to the initial idea, namely solving the problem using arithmetic sequences. | J1 designed and used the right strategy by determining the increase in the height of the Mount Anak Krakatau in meters, the difference in the height of Mount Krakatau before it erupted and the current hight of Mount Anak Krakatau, how many years both will have the same height, and in what year both will have the same height. |
| E2 | J1 made a calculation error when determining the number of visible Lego circles when there are two levels and so on. | J1 performed precise calculations to produce the correct solution to the problem. |
| E3 | J1 applied the arithmetic sequences concept in solving problems. J1 determined the second term ($T_2$) until the fourth term ($T_4$). Then J1 determined the difference of the arithmetic sequence, which is 6. However, because of a misunderstanding of the problem and miscalculation, the solution obtained is not correct. | J1 applied the correct algorithm in determining the solution to the given problem. |
| I1 | J1 interpreted the meaning of the results found that the number of visible lego circles at seventh level are 40 circles. However, the solution mentioned is wrong, causing a failure in the process of interpreting the meaning of the solution. | J1 interpreted the meaning of the results found that in 2121 the height of Mount Anak Krakatau will be the same as the height of Mount Krakatau before it erupted. |
| I2 | J1 re-checked the solution steps and re-checked that the results obtained made sense, but because of a misunderstanding of the problem, J1 did not realize that the solution obtained was wrong. | J1 was confident that the answer obtained was correct and made sense. |

Based on Table 2, in solving HOTS problem at level 5, J1 was only able to fulfill F1, F2, and E1 indicators. In this case, J1 is said to have not been able to carry out the mathematical process on HOTS problem at level 5 perfectly because the employ and interpret process were not carried out properly (Rizki & Priatna, 2019). During the interview, J1 stated that this happened because of misunderstanding of the problem. This kind of error is usually called a comprehension error (Wijaya et al., 2014). According to Sari & Wijaya (2017), the process of understanding the problem is very important and is the initial step in the process of solving

mathematical literacy problems that affect the next steps, so that the low ability to understand the problem is one of the factors in low mathematical literacy skills.

Meanwhile, in completing HOTS problem at level 6, J1 was able to fulfill almost all mathematical literacy indicators, since for indicator F2, it was not done well because J1 only wrote down the information presented in the problem directly without changing it into the appropriate mathematical language. This is in line with Cullen, et al. (2017) who stated that one of the obstacles in solving problems is representing a condition or expression using appropriate mathematical symbols or language.

The second research subject is the second junior teacher with J2 code. Figure 2 below is the answer of the second junior teacher (J2) on HOTS problems at level 5 and level 6.

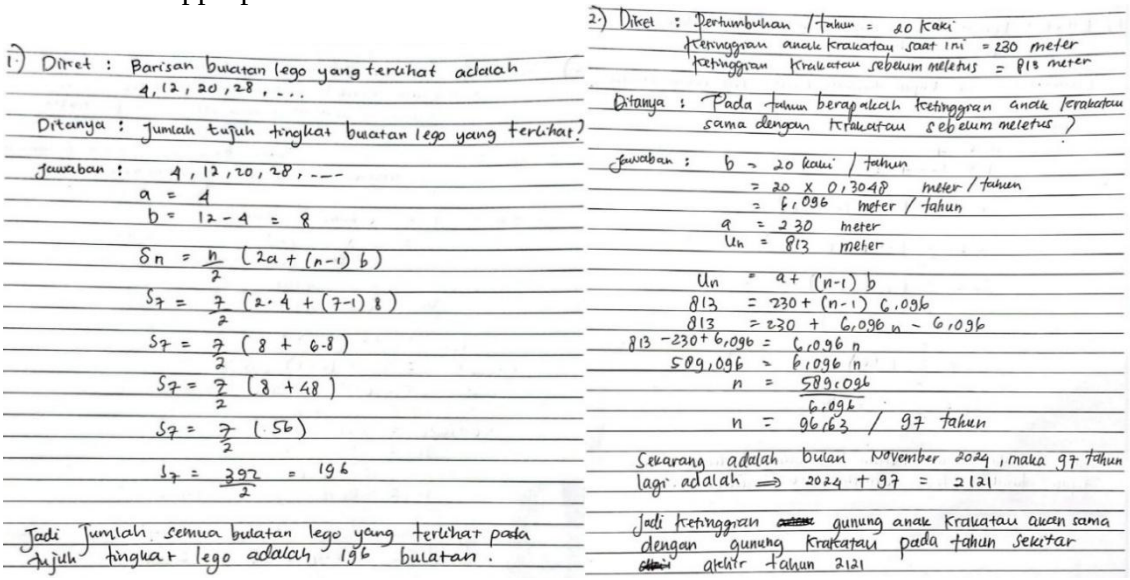


Figure 2. Answer of J2 for HOTS Problems at Level 5 (Problem 1) and Level 6 (Problem 2)

The results of the J2 answer sheets and interviews were analyzed based on the mathematical literacy indicators. Table 3 below explains the achievement of J2's mathematical literacy skills based on the mathematical literacy indicators.

Table 3. Achievement of J2's mathematical literacy skills based on mathematical literacy indicators

| Code | HOTS Problem at Level 5 | HOTS Problem at Level 6 |
|---|---|---|
| F1 | J2 was able to mention the information known in the problem, namely the number of visible lego circles at each increase in the number of lego levels are $4, 12, 20, 28, ..$ | J2 was able to mention the information known in the problem, such as the year Mount Krakatau erupted, the additional height of Mount Anak Krakatau every year, the current height of Mount Anak Krakatau, and the height of Mount Krakatau before it erupted. |
| F2 | J2 wrote the information presented in the problem using appropriate mathematical language, which are arithmetic sequence, first term $(a)$, and difference $(b)$. | J2 wrote the information presented in the problem using appropriate mathematical language, which are the difference $(b)$ as the increase of the Mount Anak Krakatau every year, first term $(a)$ as the current height of Mount Anak Krakatau, and the height of Mount Krakatau before eruption as $U_n$. |
| E1 | J2 designed and used strategies by determining the arithmetic sequence | J2 designed and used strategies by determining the increase in the height of the Mount Anak Krakatau every |

| | | |
|---|---|---|
| | formed from the visible lego circles, determining the first term ($a$), the difference ($b$), and the seventh series as the number of visible lego circles if there are seven levels. | year as the difference ($b$), the current height of Mount Krakatau as the first term ($a$), the height of Mount Krakatau before it erupted as $U_n$, and J2 finds $n$ as the period of time (in years) for the height of Mount Anak Krakatau to be the same as the height of Mount Krakatau through the aritmetic sequence formula, and adds the current year to the value of $n$. |
| E2 | J2 performed precise calculations to produce the correct solution to the problem. | J2 performed precise calculations to produce the correct solution to the problem. |
| E3 | J2 applied the concepts of arithmetic sequences and arithmetic series to solve the problem. | J2 applied the concepts of arithmetic sequences to solve the problem. |
| I1 | J2 interpreted the meaning of the results found that the number of visible lego circles when there are seven levels is 196 circles. | J2 interpreted the meaning of the results found that the height of the Mount Anak Krakatau will be the same as the heigh of Mount Krakatau before it erupted around the end of 2121. |
| I2 | J2 re-checked the solution steps to ensure the answer is correct and make senses. | J2 re-checked the solution steps to ensure the answer is correct and make senses. |

Based on Table 3, in solving HOTS problems at level 5 and level 6, J2 was able to fulfill all mathematical literacy indicators. J2 was able to choose the right strategies to work on the two HOTS problem, so that J2 got the right solutions. As Kholid, et al. (2022) explained that one of the mathematical literacy indicators is the ability to choose and plan strategies to solve contextual problems. Rawani, et al. (2019) added that the ability to determine problem-solving strategies appears in the use of various procedures to solve problems.

The third research subject is the first senior teacher with S1 code. Figure 3 below is the answer of the first senior teacher (S1) on HOTS problems at level 5 and level 6.

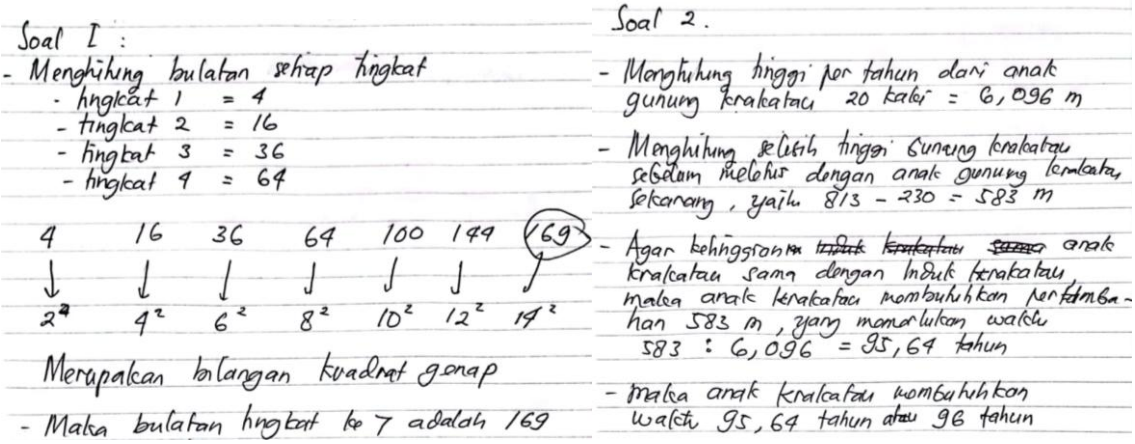

Figure 3. Answer of S1 for HOTS Problems at Level 5 (Problem 1) and Level 6 (Problem 2)

The results of the S1 answer sheets and interviews were analyzed based on the mathematical literacy indicators. Table 4 below explains the achievement of S1's mathematical literacy skills based on the mathematical literacy indicators.

Table 4. Achievement of S1's mathematical literacy skills based on mathematical literacy indicators

| Code | HOTS Problem at Level 5 | HOTS Problem at Level 6 |
|---|---|---|
| F1 | S1 was able to mention the information known in the problem, namely the number of visible lego circles at the first level, which is four circles. | S1 was able to mention the information known in the problem, namely the year Mount Krakatu erupted, the additional height of Mount Anak Krakatau, and the height of Mount Krakatau before it erupted. |
| F2 | S1 wrote the information presented in the problem directly, then changes it into a sequence of number patterns. | S1 wrote the information presented in the problem directly, without changing the problem into mathematical language. |
| E1 | S1 designed and used strategies by looking at the pattern of the number of visible lego circles at each increase in the number of lego levels, namely the pattern of even square numbers. | S1 designed and used imperfect strategies, since there was only a stage to determine the increase in the height of the Mount Anak Krakatau in meters, the difference in the height of Mount Krakatu before it erupted and the current Mount Anak Krakatau, and how many years both will have the same height. |
| E2 | S1 made a calculation error when determining the number of visible lego circles when there were seven levels. | S1 did the correct calculation, but the calculation did not reach what was asked in the problem, so the final solution of the problem was wrong. |
| E3 | S1 applied the concept of number patterns in solving problems. S1 determined the number of visible lego circles when there was only one level until when there were seven levels. Then S1 found that the number of visible lego circles forming an even square number pattern. | S1 applied the correct algorithm in determining the solution to the given problem, but there is no stage in determining in what year the Mount Anak Krakatau and Mount Krakatau before the eruption had the same height. |
| I1 | S1 interpreted the meaning of the results found that the number of visible lego circles when there are seven levels was $(14)^2 = 169$ circles. However, the solution mentioned was wrong, causing failure in the process of interpreting the meaning of the solution. | S1 interpreted the meaning of the results found that in 96 years the height of Mount Anak Krakatau will be the same as the height of Mount Krakatau before it erupted. However, the solution mentioned does not match what is asked in the problem. So that, causing failure in the process of interpreting the meaning of the solution. |
| I2 | S1 did not re-check the solution steps so S1 did not realize there was a calculation error. | S1 did not re-check the solution steps so S1 did not realize that S1 had not yet reached the final solution that answered the question in the problem. |

Based on Table 4, in solving HOTS problem at level 5, S1 was only able to fulfill F1, F2, and E1 indicators. This is because there was a calculation error so that the final solution obtained was wrong. This error is a type of mathematical processing error (Wijaya et al., 2014). Meanwhile, in solving HOTS problem at level 6, S1 was only able to fulfill F1 indicator because the final solution given by S1 did not answer the question in the problem. There is one step that has not been taken by S1 in determining the solution to the problem, namely determining in what year the Mount Anak Krakatau and Mount Krakatau before the eruption had the same hight. And for indicator F2, it was not done well because S1 only wrote down the information presented in the problem directly without changing it into the appropriate mathematical language.

Based on the interview results, S1's error in answering HOTS problem at level 5 and level 6 because S1 did not re-evaluate the steps to solve the problems that S1 had taken (indikator I2). Inaccuracy in reading problems and

doing calculations are some of the factors that cause errors in solving a mathematical problem (Harahap et al., 2019). Furthermore, research by Geraldine & Wijayanti (2022) stated that a person is said to be unable to achieve the employ and interpret indicators perfectly when they make mistakes in applying the algorithm and do not re-evaluate the results they obtain.

The fourth research subject is the second senior teacher with S2 code. Figure 4 below is the answer of the second senior teacher (S2) on HOTS problems at level 5 and level 6.

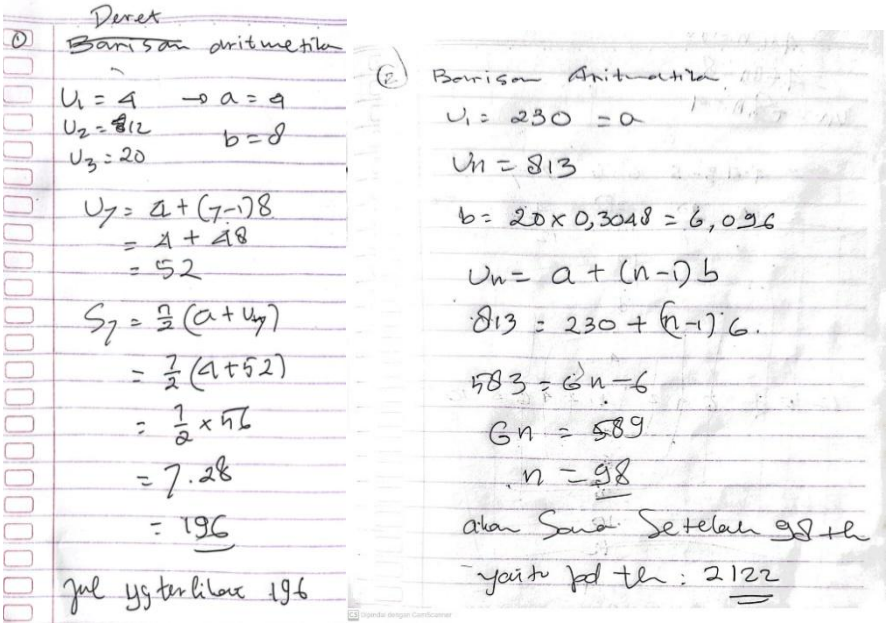


Figure 4. Answer of S2 for HOTS Problems at Level 5 (Problem 1) and Level 6 (Problem 2)

The results of the S2 answer sheets and interviews were analyzed based on the mathematical literacy indicators. Table 5 below explains the achievement of S2's mathematical literacy skills based on the mathematical literacy indicators.

Table 5. Achievement of S2's mathematical literacy skills based on mathematical literacy indicators

| Code | HOTS Problem at Level 5 | HOTS Problem at Level 6 |
|---|---|---|
| F1 | S2 was able to mention the information known in the problem, namely the number of visible lego circles at the first level, which is four circles. | S2 was able to mention the information known in the problem, such as the year Mount Krakatau erupted, the additional height of Mount Anak Krakatau every year, the current height of Mount Anak Krakatau, and the height of Mount Krakatau before it erupted. |
| F2 | S2 changed mathematical problems into mathematical language in the form of symbols related to the concepts of arithmetic sequences and arithmetic series. | S2 changed mathematical problems into mathematical language in the form of symbols related to the concept of arithmetic sequences. |
| E1 | S2 designed and used strategies, such as using an arithmetic sequence to determine the number of visible lego circles when there are seven levels and an arithmetic series to determine the number of visible lego circles when there are seven levels. | S2 designed and used strategies, such as using arithmetic sequences to determine how long (in years) Mount Anak Krakatau will have the same height as Mount Krakatau before it erupted. |
| E2 | S2 performed precise calculations to get the right solution to the problem. | S2 performed precise calculations to get the right solution to the problem. |

| | | |
|---|---|---|
| E3 | S2 applied the concepts of arithmetic sequences and arithmetic series to solve problems. | S2 applied the concepts of arithmetic sequences to solve problems. |
| I1 | S2 interpreted the meaning of the results found that the number of visible lego circles when there are seven levels was 196 circles. | S2 interpreted the meaning of the results found that in 2122 the height of Mount Anak Krakatau will be the same as the height of Mount Krakatau before it erupted. |
| I2 | S2 re-evaluated the solution steps to ensure the answer is correct and reasonable. | S2 re-evaluated the solution steps to ensure the answer is correct and reasonable. |

Based on Table 5, in solving HOTS problems at level 5 and level 6, S2 was able to fulfill all mathematical literacy indicators. As research by Alvina & Hastari (2023) stated that someone is said to have good mathematical literacy skills when they are able to achieve the formulate, employ, and interpret indicators in solving problems related to mathematical literacy.

Judging from HOTS problem at level 5 to measure mathematical literacy skills, J1 was only able to fulfill F1, F2, and E1 indicators because J1 misunderstood the prolem so that J1 get the wrong solution. S1 was only able to achieve F1, F2, and E1 indicators because S1 made a mistake in calculating so that S1 produced the wrong solution. Meanwhile, J2 and S2 were able to fulfill the overall mathematical literacy indicators.

Judging from HOTS problems at level 6 to measure mathematical literacy skills, J1 was able to fulfill all mathematical literacy indicators but for F2 indicator it had not been done well. S1 was only able to fulfill F1 indicator since S1 made a mistake in reading the problem so that the final solution obtained did not answer what was asked by the problem. And for indicator F2 it had not been done well. Meanwhile, J2 and S2 were able to achieve the overall mathematical literacy indicators. In this problem, there are differences in the final answer of J1, J2, dan S2 due to rounding of numbers during the calculation.

Based on the research results that have been obtained, there are junior and senior teachers who have not been able to achieve the overall mathematical literacy indicators. This shows that there are still teachers who do not have good mathematical literacy skills. In line with research by Suharta & Suarjana (2018) that many teachers still have difficulties when working on problems related to mathematical literacy skills. Podkhodova, et al. (2020) also stated that there are mathematics teachers who still have difficulty in solving mathematical problems.

Furthermore, the theory that mathematical literacy develops basic skills that are crucial for students' intellectual growth, develops logical thinking, analytical and rational thinking skills, and becomes the basis for making the right decisions in academic fields and related to the complexity of problems in everyday life (Sitopu et al., 2024) requires the development of students' mathematical literacy skills in schools. Teachers are highly expected to provide learning oriented towards mathematical literacy, for example by giving problems related to the development of mathematical literacy skills (Lestari et al., 2021; Rachmaningtyas et al., 2022). However, if the teacher's mathematical skills are inadequate, then the teacher cannot decide on the correctness of the students' answers (Tichá & Hošpesová, 2013). As Blömeke, et al. (2020) and Yang & Kaiser (2023) stated that the competency profile of mathematics teachers is related to their quality in

teaching.

Therefore, teachers need speecial training related to the development of teacher mathematical literacy so that they are able to develop activities that can develop students' mathematical literacy skills in schools (Podkhodova et al., 2020). Developing students' mathematical literacy skills is very important because students with mathematical literacy will have an advantage in navigating the demandas of the modern global environment. The integration of mathematical literacy also contributes to increasing students' global competitiveness, and strong mathematical literacy will be an important asset for students in facing an increasingly competitive job market and the complexity of a changing world (Sitopu et al., 2024).

## CONCLUSION

Based on the research results and discussion that have been described, it can be concluded that in solving HOTS problem at level 5, there was junior teacher who could only able to fulfill 3 of the 6 mathematical literacy indicators due to misunderstand the problem, so the solution was wrong. In addition, there was senior teacher who could only able to fulfill 3 of the 6 mathematical literacy indicators due to a miscalculation so the final solution was wrong. However, other junior and senior teachers were able to fulfill the overall mathematical literacy indicators. In solving HOTS problems at level 6, there was junior teacher who had not fulfilled one of the mathematical literacy indicators. In addition, there was senior teacher who could only able to fulfill one of the mathematical literacy indicators due to a reading error of the problem so that the final solution obtained did not answer the question from the problem. However, other junior and senior teachers were able to fulfill the overall mathematical literacy indicators. Thus, there are still both junior and senior teachers who have not been able to solve HOTS problems related to mathematical literacy skills properly. This shows that there are still teachers who do not have good mathematical literacy skills

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