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An Analysis of Mathematical Literacy Process on PISA Test for System of Linear Equations in Two Variables

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ABSTRACT

Mathematical literacy is a crucial competency that requires students to formulate, employ, and interpret mathematics in various contexts. However, Indonesian students' mathematical literacy achievements in the PISA assessment are still relatively low. This research aims to analyze the stages in students' mathematical literacy process in solving PISA problems on systems of linear equations in two variables (SPLDV). This research used a qualitative descriptive approach involving 40 eighth grade students at a junior high school in Semarang City. Data collected through mathematical literacy tests, observations, and in-depth interviews using triangulation. Data analysis through data reduction, data presentation, and inductive conclusion drawing. The research results show variation in student abilities at each stage of the mathematical literacy process. Some students were able to systematically go through all stages, from understanding the problem, formulating the problem, applying concepts and procedures, to interpreting and concluding the results. However, the others experienced difficulties, especially at the stage of formulating the mathematical problem into a mathematical model and interpreting the results in a real-world context. Common errors included a lack of thoroughness in algebraic operations, failing to verify the results first, and failing to relate the mathematical findings to the problem situation. The mathematical literacy process: understanding the problem, formulating a model, applying concepts and procedures, interpreting results, and drawing conclusions. The biggest challenges occur at the formulation and interpretation stages. This requires context based and experiential learning, as well as learning strategies that encourage mathematical representation, reasoning, and critical evaluation to improve students' mathematical literacy.

Keywords: Mathematical Literacy, PISA Test, SPLDV

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INTRODUCTION

Humans are social creatures who always need education in their daily lives (Khalil et al., 2024). This is because education is something that must be undertaken by humans in order to become quality beings so that it can be used as a benchmark for the development of a nation (Ritonga & Hasibuan, 2022). This is also in line with (Andriawan et al., 2018) which states that education is a valuable element in determining a person's progress. One of the goals of the Indonesian nation is to improve the lives of the nation. This can be achieved, among other things, through quality education (Kustini, 2016). According to UNESCO's 2023 Global Education Monitoring Report, there are three factors that are challenges to education in the current era, namely equality and inclusion, quality, and efficiency of education.

The government has made various efforts to improve the quality of education, including the Merdeka Belajar (Freedom to Learn) program. One such program is the policy to abolish the

National Examination (UN=Indonesian). This elimination of the UN has been replaced by the National Assessment (AN=Indonesian). The National Assessment is a new educational evaluation initiated by the government, consisting of three parts: the Minimum Competency Assessment (AKM=Indonesian), a character survey, and a learning environment survey (Wardono et al., 2024); (Setiawan et al., 2023, 2024). The national assessment was implemented to shift the paradigm of educational evaluation as a form of evaluation and mapping of the education system, encompassing input, process, and outcomes. The Minimum Competency Assessment (AKM) is used to measure reading and mathematical literacy (numeracy) outcomes (Kusuma et al., 2021); (Setiawan et al., 2024); (Sayekti et al., 2022).

The Organization for Economic Cooperation and Development (OECD) states that mathematical literacy is the ability of students to formulate, apply, and interpret mathematics in various contexts, including mathematical reasoning and also using mathematical concepts, procedures, and facts (OECD, 2023). Mathematical literacy as knowledge to know and apply basic mathematical concepts in everyday life (Efriani et al., 2019;Dewantara et al., 2015; Fery et al., 2017). Mathematical literacy is also the most important skill to support students' mathematical abilities (Kholid et al., 2022); (Herman et al., 2022). The government has made various efforts, including including Indonesia in the Programme for International Student Assessment (PISA=Indonesian), but Indonesian students' mathematical literacy remains relatively low. This is evidenced by the 2018 PISA results, which showed Indonesia ranked 72nd with a score of 379 (Kemendikbudristek, 2023).

In the 2022 PISA results, Indonesia's mathematical literacy score dropped to 366, compared to 472 for OECD countries, ranking 70th out of 81 participating countries. Indonesian students only achieved level 2 in mathematical literacy, with a proportion of 18%, much lower than the OECD average of 69%. Almost no students in Indonesia achieved level 5 or 6 in the 2022 PISA mathematical literacy test, with an OECD average of 9% (Kemendikbudristek, 2023). Achievement Trends in Reading, Mathematics, and Science can be seen in Figure 1.

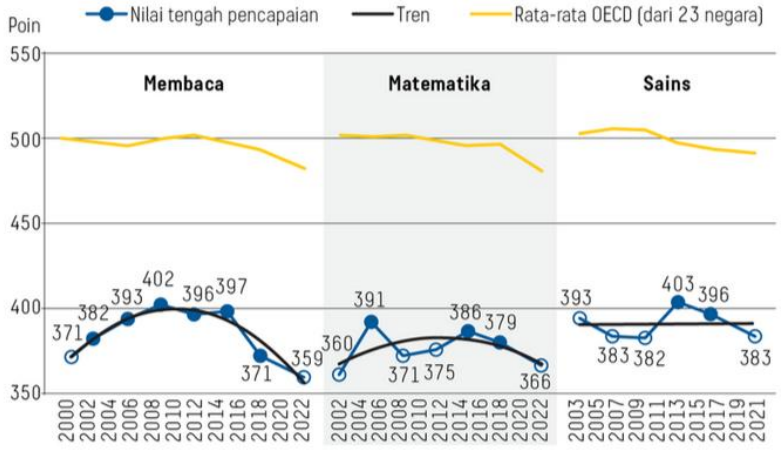


Figure 1. Achievements of Indonesian Mathematical Literacy

Based on preliminary research conducted by researchers at a Junior High School (SMP) in Semarang City, it shows that students' mathematical literacy is still relatively low. This is evidenced by the fact that 23% of students can achieve minimum competency. Based on the 2024 SMP education report, it shows that students' mathematical literacy is still classified as moderate with an achievement of 69.05%. This achievement still ranks lower middle at the Regency/City level even though the achievement value is considered moderate. This is because the proportion of students with mathematical literacy reaching minimum competency has decreased by 24.76% with the achievement in 2024 being 28.57%. The proportion of students with mathematical literacy below the minimum competency also decreased by 7.46% compared to 2023 at 28.89%. This also occurred in the algebra domain, which also decreased by 0.23 compared to the 2023 achievement of 57.59 and ranked lower middle at the Regency/City level. In the process aspect, there was no decline, but the two process aspects, namely applying and reasoning, were still at the lower middle ranking at the Regency/City level.

These conditions indicate that students' mathematical literacy needs to be improved through meaningful, contextual, and student-centered learning innovations. Learning needs to provide real-life experiences that encourage students to actively think critically, solve problems, and relate mathematical concepts to everyday life. Therefore, an analysis of students' mathematical literacy process is needed to improve their mathematical literacy through appropriate stages of the student's mathematical literacy process. The research question is: What are the stages of students' mathematical literacy process in the PISA test questions on systems of linear equations in two variables?

METHOD

This research is a qualitative descriptive study that describes the process and results of the mathematical literacy stages. The system of linear equations in two variables was taught to 40 students at a junior high school in Semarang City, Indonesia who were all at class VIII. The examination of the mathematical literacy findings of 40 students yielded three answer categories, with three answers to each question divided. Data was gathered through evaluation tests, observations, and in-depth interviews as part of triangulation method. A three-tiered evaluation test was devised: simple, medium, and complete.

Triangulation was used as a data-gathering method, which involved conducting experiments, observations, and in-depth interviews to gather information (Sukestiyarno, 2020). The data analysis used an inductive approach where conclusions are drawn from small case investigations in detail to provide a big picture (Sukestiyarno, 2020). The data analysis consisted of data reduction, data presentation, and concluding. The data reduction was made by coding the student answers. The coding is used to facilitate the tracking of important data about the exposure of existing data. after the data is reduced, the next step is to present the data by verifying the data with in-depth interviews. The last step is to make conclusions from the data in the field.

RESULT AND DISCUSSION

In this study, students were asked to work on three mathematical literacy problems and the results of the analysis of the three mathematical literacy problems are as follows. The first problem is Nova went to the Sneakers Shop to buy a pair of sandals and shoes because there was a new brand. As soon as she arrived at the shop, Nova thought about giving her sister a birthday present of the same type of sandals but she did not know her sister's foot size. The seller gave Nova leeway to exchange the sandals if the size was not right. Nova paid for 2 pairs of sandals and a pair of shoes for Rp285,000.00. Nova returned home and found that the sandals she bought for her sister were too big. Her sister suggested exchanging the pair of sandals for the same pair of shoes as Nova. The price of the pair of shoes turned out to be more expensive, so she had to pay an additional Rp45,000.00. How much did a pair of Nova's shoes cost? The results of the students' work can be seen in Figure 2.. Students' Work Results on Number 1

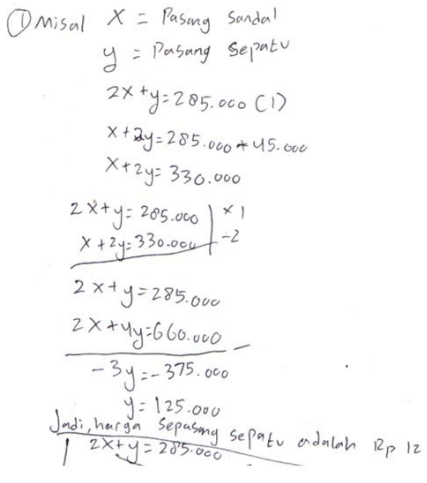


Figure 2A

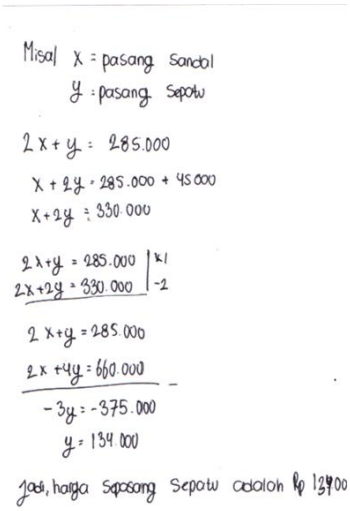


Figure 2B

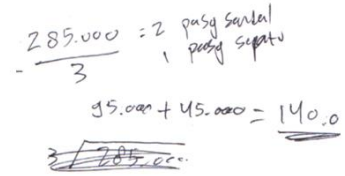


Figure 2C

Based on Figure 2A, it can be explained that student A1 has gone through the stages of the mathematical literacy process quite systematically. At the stage of understanding mathematical problems, student A1 appears to be trying to understand the context of the problem correctly. He realizes that there are two types of goods: sandals and shoes, with the information that two pairs of sandals and one pair of shoes cost Rp285,000.00. In addition, student A1 also understands that there is an additional condition, namely that one pair of sandals and two pairs of shoes have a higher price of Rp45,000.00 than the first condition. This understanding shows that student A1 is able to clearly identify the known and asked information. However, student A1 has not yet written down what is known in the problem or problem. Based on the results of the interview, student A1 revealed that he first read the problem several times to ensure important information and marked the numbers related to the price, so that it would be easier to write down the known data.

In the mathematical problem formulation stage, student A1 transformed the contextual problem into a mathematical model using algebraic symbols. Student A1 assumed x to be the price of a pair of sandals and y to be the price of a pair of shoes. Then, student A1 wrote two linear equations: $2x + y = 285,000$ and $x + 2y = 330,000$. This step demonstrated student A1's ability to correctly translate verbal information into symbolic representation. Based on the interview, student A1 stated that he was accustomed to using the symbols x and y in solving problems with systems of linear equations in two variables (SPLDV) because they were easier to remember and helped in the elimination process. Student A1 also mentioned that the formula was created so that the relationship between sandals and shoes could be compared mathematically.

The next stage, namely using mathematical concepts, procedures, facts, and reasoning, was carried out quite well by student A1. Student A1 used the elimination method to solve the SPLDV. Student A1 multiplied one of the equations to make the coefficient of one variable the same, then subtracted it to eliminate the variable. Student A1 carried out the calculation process sequentially and orderly until finding the value of $y = 125,000$. The elimination procedure used showed that student A1 understood the basic concept of SPLDV and was able to apply the solution algorithm correctly. Based on the interview results, student A1 said that he chose the elimination method because he thought it was simpler and easier than substitution and found the result faster. Student A1 also added that the step of subtracting two equations helped him see the difference in value between the two conditions given in the problem.

In the stage of interpreting, applying, and evaluating the results of a mathematical process, Student A1 interpreted the value obtained as the price of a pair of shoes, namely Rp125,000.00. Student A1 also rewrote the initial equation $2x + y = 285,000$ to substitute the value of y to find the price of the sandals. Although in Student A1's work, he did not write the final result for the sandals explicitly, it was apparent that he understood the relationship between variables and attempted to re-check the suitability of the results obtained with the context of the problem. Based on the interview results, Student A1 admitted that he had re-checked the results of his calculations to ensure there were no errors in addition or subtraction. Student A1 said, "I tried to check again, sir, because I was afraid of miscalculation, but it turns out that the question only asked about the price of a pair of shoes." This shows the existence of evaluative and reflective abilities in assessing the results.

In the final stage, the results were summarized. Student A1 concluded that the price of a pair of shoes is Rp125,000.00. This demonstrates that student A1 is able to connect the results of mathematical calculations to real-life contexts. Based on the interview results, student A1 stated that he was confident in the results he obtained because the steps used were in accordance with mathematical procedures and logic. Student A1 added that this method is often used in SPLDV learning in class, so he felt confident in his answers. Based on the explanation of the stages of the mathematical literacy process, it can be concluded that student A1 is good at solving questions or problems based on the stages of the mathematical literacy process.

Based on Figure 2B, it can be explained that student B1 has gone through the stages of the mathematical literacy process, but there are still stages that have not been achieved properly. At the stage of understanding mathematical problems, student B1 has understood the context of

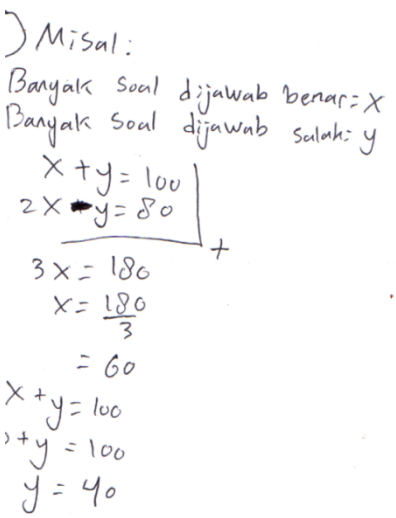
the problem correctly. Based on the results of the interview, student B1 revealed that he understood the problem first according to the teacher's instructions and noted the important or main things in the problem or problem. Based on these important or main notes, student B1 was able to interpret the data known from the problem, but student B1 did not write the known data in the problem on his worksheet. At the stage of formulating mathematical problems, student B1 was also able to write the problem or mathematical problem into a mathematical model. This can be seen from the example made by student B1, namely x to pair of sandals and y to pair of shoes. Student B1 wrote the example into a complete mathematical form into two-variable linear equations. Based on the interview that has been conducted with student B1, it was found that student B1 did such a process because it made it easier to calculate the results later.

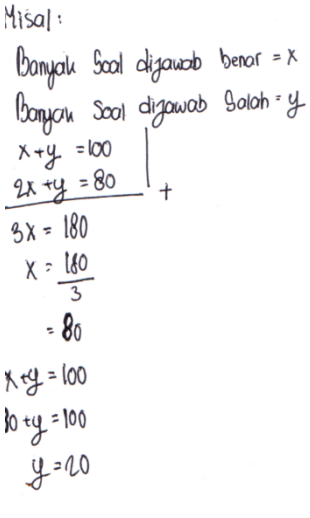
Student B1 also used concepts, procedures, facts, and reasoning to solve the problem. Student B1 used the elimination method to solve the problem. Student B1 had carried out the calculation process sequentially until he found the result of the variable y, but the calculation of the result was wrong in the division process. This resulted in an error in the result obtained in determining the price of a pair of shoes. Based on the results of the interview, student B1 stated that when taught, if the variables are not the same, they are multiplied by their opposites, but if they are the same, they can be calculated directly using subtraction or addition adjusted to the context. In the incorrect division process, student B1 admitted to experiencing inaccuracy in calculating the result. This will result in errors in the next process or stage. This can be seen in the stages of interpreting, applying, and evaluating the results of a mathematical process. Student B1 made an error that impacted the previous process or stage, namely interpreting the price of a pair of shoes, which is Rp134,000.00 (or the value of y).

Based on the interview, student B1 admitted that he did not recheck his calculation results because he had already found the results and was too lazy to check them again. At the stage of concluding the results obtained, he automatically also experienced errors in his grade. Student B1 did write a conclusion, but his grade was incorrect. Based on the explanation of the stages of the mathematical literacy process, it can be concluded that student B1 is not optimal/good at solving problems or questions based on the stages of the mathematical literacy process. Student B1 is still not optimal in using mathematical concepts, procedures, facts, and reasoning; interpreting, applying, and evaluating the results of a mathematical process; and concluding the results obtained.

Based on Figure 2C, it can be explained that student C1 is very lacking in fulfilling the stages of the mathematical literacy process. This can be seen that student C1 immediately divided 285,000 by 3 which is not in accordance with the context of the problem or question that has been provided. The stages starting from understanding the mathematical problem to concluding the results obtained are not visible at all in the work of student C1, therefore it can be concluded that student C1 still has difficulty in fulfilling the stages of the mathematical literacy process. Based on the interviews that have been conducted, student C1 admitted to not understanding what the question is asking, lazy to read, and confused by questions like that so lazy to think.

The second question is that Ridwan is taking a civil servant selection exam and must complete the first stage of the selection, namely the Basic Competency Test (SKD), which has 100 questions. Correct answers are given a score of 2, and incorrect answers are given a score of -1. In the score announcement via streaming, Ridwan received a score of 80. Determine the number of questions Ridwan answered incorrectly! The results of the student's work can be seen in Figure 3.





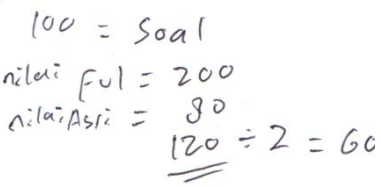


Figure 3A **Figure 3B** **Figure 3C**

Figure 3. Students' Work Results on Number 2

Based on Figure 3A, it can be explained that student A2 has gone through the stages of the mathematical literacy process well. At the stage of understanding mathematical problems, student A2 demonstrated the ability to understand the context of the problem well. Based on Figure 3A, the student recognized that the problem was related to the number of questions answered correctly and incorrectly in a test with a total of 100 questions. This step shows that student A2 understands the meaning of each element of the problem but has not written down what is known in the problem. Based on the interview that has been conducted, student A2 explained that initially he read the problem several times to understand the context and if he did not understand it, he needed to reread the problem. This statement shows that student A2 uses the strategy of rereading and understanding the context before performing calculations and also shows the ability to understand the problem conceptually rather than simply copying data.

Based on the results of student A2's work, student A2 has demonstrated good mathematical problem formulation by modeling a problem into a mathematical form. This can be demonstrated through student A2 who wrote the example of the number of questions answered correctly = x and the number of questions answered incorrectly = y. Student A2 implemented the example into the problem by forming two equations where the first equation shows the number of questions while the second equation shows the relationship between the value of questions answered correctly and incorrectly with the predetermined score. This indicates that student A2 has been able to transform verbal information into an appropriate mathematical model. Based on the interview, student A2 said "I know that the number of questions is one hundred, which means that the correct and incorrect ones must be added up to one hundred too." Student A2 also continued by saying "I made two equations because I thought if there was only one, the result would not be able to be found. So I made another one from the final value in the question." Student A2's statement shows that student A2 understands the need for two mathematical relationships or equations to solve for two unknown variables.

The next step is to use mathematical concepts, procedures, facts, and reasoning. Student A2 chose the elimination method to solve the problem. Based on Figure 3A, it was found that the student had found the final result of x, which was 60 and substituted it into one of the equations to get the final result of y = 40. This shows that the student had used algebraic concepts and reasoning correctly and logically. Based on the interview results, student A2 said, "I chose the elimination method because it was the easiest, just subtract one letter so that one letter is missing. Because using substitution sometimes makes me confused and dizzy." This

shows that student A2 not only memorized the procedure but also chose a strategy based on an understanding of a concept. The next step, student A2 had not interpreted the meaning of the final result into the context of the problem, namely there were 60 questions answered correctly and 40 questions answered incorrectly even though the results were in accordance with the example. This requires re-examination and evaluation from student A2. After finding the final result, they must link it back to the real situation or context of the problem.

Based on the interview, student A2 said, "I double-checked because I was afraid of miscalculation, so I made sure the results matched the total. It turns out that 60 plus 40 is 100, which means it matches. If the results don't match, it means there was a miscalculation." This shows that student A2 has the self-awareness to independently re-check the steps and results to ensure their correctness, but student A2 forgot to write them back into the real situation or context of the problem. At the stage of concluding the results obtained, student A2 has not shown it in writing but has shown it implicitly. This can be seen from the final results written by student A2. Based on the interview, student A2 said, "So, in conclusion, I answered 60 correctly and 40 incorrectly. I am sure because all the calculations match or are the same." This confirms that student A2, even though he did not write the conclusion at the end, understood its meaning.

Based on Figure 3B, it can be explained that B2 students are not optimal in the stages of the mathematical literacy process. At the stage of understanding mathematical problems, B2 students are able to understand what is meant by the problem. However, B2 students do not write what is known in the problem and immediately write the other stages. Based on the results of the interview, B2 students admitted that because they saw the results of their friends' work, they wrote the same without considering the context of the problem. At the stage of formulating mathematical problems, B2 students are not optimal in writing problems or mathematical problems into mathematical models. This can be seen from the second equation which is in the form of an addition operation sign when it should be a subtraction operation. However, B2 students have been able to show an example, namely x being the number of questions answered correctly and y being the number of questions answered incorrectly. B2 students wrote these examples into complete mathematical form as linear equations with two variables despite writing the operation form incorrectly. Based on interviews that have been conducted with B2 students, it was found that B2 students carried out such a process because it is easy and simple.

Student B2 also used concepts, procedures, facts, and reasoning to solve the problem. Student B2 used the elimination method to solve the problem. Student B2 had performed the calculation process sequentially until finding the result of variable x, but the calculation of the result encountered an error in the division process. This resulted in the obtained result being incorrect in determining the number of correct questions. Student B2 substituted the value of variable x into another equation to obtain the value of variable y. In the incorrect division process, student B2 admitted to experiencing inaccuracy in calculating the result. This will result in the next process or stage also experiencing errors. This can be seen in the stages of interpreting, applying, and evaluating the results of a mathematical process. Student B2 experienced errors that impacted the previous process or stage, namely the interpretation of many incorrect questions (or the value of y). Student B2 also did not rewrite it into the real context or the problem being asked only after knowing the final results of x and y and considered it complete when there was still a process of returning to the context that student B2 had not done.

Based on the interview, student B2 admitted that he did not recheck his calculation results because he had already found the results and was lazy to check them again. At the stage of concluding the results obtained, he automatically also experienced errors in his grades. Student B2 did not write a conclusion based on the results of his work. Based on the explanation of the stages of the mathematical literacy process, it can be concluded that student B2 is not optimal/good in solving questions or problems based on the stages of the mathematical literacy process. Student B2 is still not optimal in formulating mathematical problems; using mathematical concepts, procedures, facts, and reasoning; interpreting, applying, and evaluating

the results of a mathematical process; and concluding the results obtained. Based on Figure 3C, it can be explained that student C2 is very lacking in fulfilling the stages of the mathematical literacy process. This can be seen that student C2 immediately divided 120 by 2, which is not in accordance with the context of the problem or question provided. The stages starting from understanding the mathematical problem to concluding the results obtained are not visible at all in the work of student C2, therefore it can be concluded that student C2 still experiences difficulties in fulfilling the stages of the mathematical literacy process. Based on interviews that have been conducted, student C2 admitted to being lazy to calculate because it is confused by questions in the form of literacy.

The third question is that Padang ferry tickets can now be ordered online. As a form of promotion to passengers, the management provides a 20% discount to passengers for booking these tickets. Tickets consist of two types, namely adult tickets and children's tickets (for ages under 18). Mr. Agus, his wife, and his 12-year-old child ordered ferry tickets online for Rp335,000.00. Meanwhile, Andi (18 years old) and his two younger siblings, aged 10 and 12, planned to go on vacation and cross the island via Padang port. Andi ordered online for Rp295,000.00. How much is the ferry ticket price for adults and children's tickets (ages under 18) for offline purchases? The results of the students' work can be seen in Figure 4.

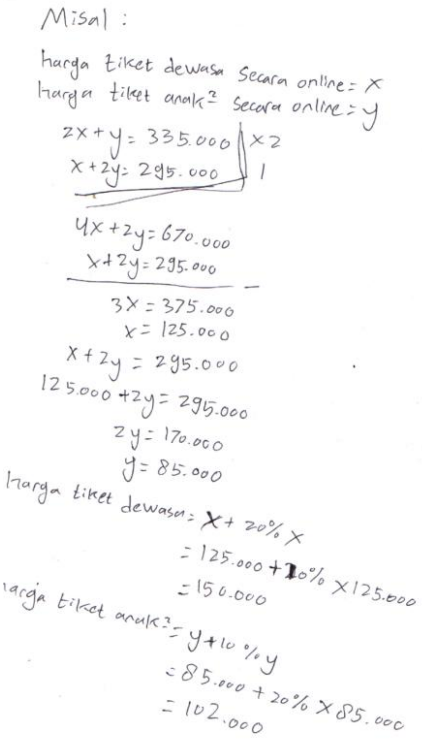


Figure 4A

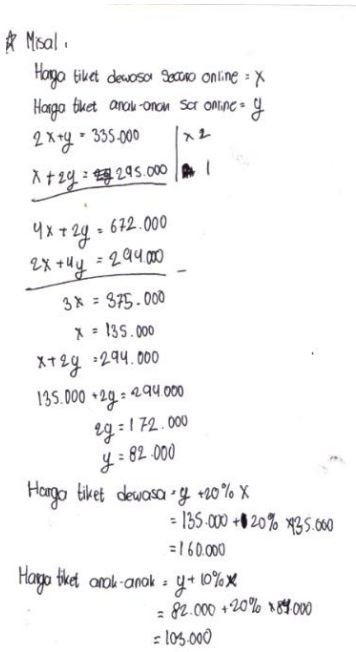


Figure 4B

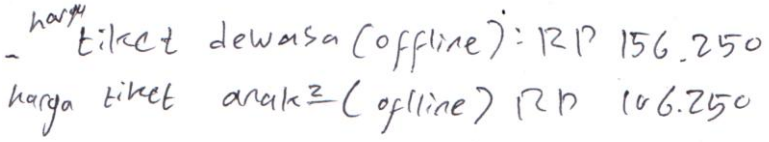


Figure 4C

Figure 4. Students' Work Results on Number 3

Based on Figure 4A, it can be explained that the solution process carried out by student A3 shows the stages of the mathematical literacy process that are well developed. At the stage of understanding the mathematical problem, student A3 attempted to identify important information from the problem, namely the existence of two types of tickets, namely adult tickets

and child tickets, each of which has a certain price when purchased online. In addition, student A3 understood that there were two transaction conditions with different total prices, namely Rp335,000.00 and Rp295,000.00. Although student A3 was able to explain what was known in the problem, student A3 did not write this on student A3's worksheet. Based on the interview results, student A3 said that he read the problem repeatedly to ensure which information was data, which was a question, and which was a relationship between prices. Student A3 said, "I have to know first, sir, the price sought and the relationship between adult and child tickets. If I don't understand that part, I can't make the equation."

In the mathematical problem formulation stage, student A3 successfully converted a contextual situation into a mathematical model using variables. Student A3 assumed the price of an adult ticket as x and the price of a child ticket as y. Student A3 then wrote it into two linear equations or mathematical forms, namely $2x + y = 335,000$ and $x + 2y = 295,000$, which are mathematical representations of two different ticket purchasing conditions. Based on the interview results, student A3 explained that he chose to use variables because it was easier than directly dividing or guessing the price and he was used to using this method because it was often used in learning. This demonstrates student A3's ability to transform real problems into symbolic forms appropriately.

In the stage of using mathematical concepts, procedures, facts, and reasoning, student A3 used the elimination method to solve the SPLDV. He multiplied the second equation by a certain factor so that the coefficients matched and could be eliminated. Student A3 then subtracted between the equations until he obtained the result $x = 125,000$. Student A3 then substituted the x value into one of the equations to obtain the value $y = 85,000$. This process shows that student A3 understands the concept of elimination, facts about linear relationships, the process of algebraic operations, and mathematical reasoning to solve problems. Based on the interview results, student A3 stated that he chose elimination because it was faster and less complicated and he felt this method helped him find the relationship between the two equations.

At the stage of interpreting, applying, and evaluating the results of a mathematical process. Student A3 does not only stop at the SPLDV results, but also continues to apply these results to the context of ticket prices after discounts. Student A3 calculates the price of an adult ticket to $x + 20\%x$ which results in 150,000 and the price of a child ticket to $y + 20\%y$ which results in a final result of 102,000, however, in the solution, student A3 makes a mistake in writing where after writing $x + 20\%x$ it becomes $125,000 + 10\% \times 125,000$. Writing 10% should be 20% even though student A3 writes it that way, but the final result is still the same, namely 150,000. Student A3 needs to re-examine what he has done. In the stage of concluding the results obtained, student A3 concluded that the price of an adult ticket online is Rp125,000.00 and the price of a child ticket is Rp85,000.00, while the offline price for an adult ticket is Rp150,000.00 and a child ticket is Rp102,000.00. Student A3 was able to clearly relate all the calculation results to the context of the problem. Based on the interview results, student A3 stated that he felt confident in his answer because the steps he took were logical and followed the procedures he had learned. He said, "If the steps are correct from the beginning, the final result will definitely follow." This shows confidence and a deep understanding of the process being carried out.

Based on Figure 4B, it was shown that at the stage of understanding mathematical problems, student B3 was able to identify that the problem was related to determining the price of adult and child tickets based on two different online learning conditions. Important information such as the total price of IDR 335,000.00 and IDR 295,000.00 for certain ticket combinations was successfully recorded by the student. Based on the interview results, student B3 explained that he read the problem several times while marking the numbers that appeared. Student B3 said, "I have to make sure the number of tickets and the total money is correct first so that I don't make mistakes when making the equation." This shows that student B3 understands the context of the problem and is able to sort out relevant information.

In the mathematical problem formulation stage, student B3 then transformed contextual information into a mathematical model by assuming x as the adult ticket price and y as the

child ticket price. Student B3 wrote two linear equations, namely 2x + y = 335,000 and x + 2y = 295,000. This ability shows that student B3 can connect verbal information into symbolic form appropriately. Based on the interview results, student B3 explained that he used SPLDV because the problem format shows two variables and two conditions that can be compared. He said, "If there are two conditions like this, I usually use SPLDV, because I will definitely find two different prices." This shows good mathematical representation skills. In the stage of using mathematical concepts, procedures, facts, and reasoning as seen in Figure 4B, student B3 chose the elimination method to solve the SPLDV problem.

Student B3 multiplies the first equation by a factor of 2 and the second equation by a factor of 1 so that both equations can be subtracted. However, student B3 makes an error during the multiplication, which will automatically affect the results of the subsequent stages of the mathematical literacy process. Because the error in the second stage will affect the third to fifth stages, student B3 has not optimally carried out the stages in the mathematical literacy process. Student B3 is only able to complete the stages in the mathematical literacy process, namely the stages of understanding mathematical problems and formulating mathematical problems. Based on Figure 4C, it can be explained that C3 students are very lacking in fulfilling the stages of the mathematical literacy process. This can be seen from the C3 students directly writing the adult ticket price (offline) as Rp156,250.00 and the child ticket price (offline) as Rp106,250.00, which is not in accordance with the context of the problem or question that has been provided. The stages starting from understanding the mathematical problem to concluding the results obtained are not visible at all in the results of C3 students, therefore it can be concluded that C3 students still experience difficulties in fulfilling the stages of the mathematical literacy process. Based on the interviews that have been conducted, C3 students admitted to being lazy to calculate because they are confused by literacy-shaped problems because they do not understand the stages in the mathematical literacy process well. Based on the research results, the design of the stages in the new mathematical literacy process can be made into 5 stages as can be seen in Table 1.

Table 1. New Stages of the Mathematical Literacy Process

Stages	Stages of Mathematical Literacy	Description
Stage 1	Understanding mathematical problems	Students are able to understand problems and identify significant variables.
Stage 2	Formulating mathematical problems	Students are able to change problems into appropriate mathematical forms, languages, or models.
Stage 3	Using mathematical concepts, procedures, facts, and reasoning	Students are able to apply facts, rules, algorithms, and mathematical structures in finding solutions.
Stage 4	Interpreting, applying, and evaluating the results of a mathematical process	Students are able to interpret and evaluate mathematical solutions to real problems.
Stage 5	Summarizing the results obtained	Students are able to draw conclusions from the results obtained

DISCUSSION

The results of the analysis of the stages in the process of students' mathematical literacy show that the process of mathematical literacy does not occur instantly, but rather through tiered stages including understanding the problem, formulating the problem mathematically, using concepts and procedures, interpreting and evaluating the results, and drawing up final conclusions. The novelty of this research lies in its comprehensive analysis of students' mathematical literacy processes in solving SPLDV problems by integrating each literacy stage with students' cognitive characteristics and contextual reasoning abilities. Unlike previous studies that generally focus only on final achievement or procedural ability, this study explores in depth how students transition from understanding contextual problems to constructing

mathematical models, applying procedures, interpreting results, and formulating conclusions. In addition, this study provides a more holistic description of students' literacy processes by emphasizing reflective reasoning and contextual evaluation at every stage of mathematical problem solving.

This finding is in line with global literature reviews which state that mathematical literacy is a complex cognitive process that requires an understanding of context, representation, reasoning, and interpretation. (Muhaimin et al., 2024); (Almarashdi & Jarrah, 2023; Bansilal & Debba, 2012; Canbazoğlu & Tarim, 2020; Herman et al., 2022; Heyd-Metzuyanim et al., 2021). In the context of SPLDV, this study found that students demonstrate different levels of achievement at each stage of mathematical literacy. At the problem understanding stage, some students were able to identify important information and contextual meaning correctly, while others still experienced difficulties in recognizing relevant variables and relationships within the problem. At the mathematical formulation stage, many students encountered obstacles in translating verbal information into valid mathematical models. Furthermore, although most students could perform algebraic procedures mechanically, not all students understood the conceptual meaning behind the procedures they used. At the interpretation and conclusion stages, only students with strong contextual reasoning abilities were able to evaluate and communicate their solutions appropriately according to the context of the problem. These findings indicate that mathematical literacy involves interconnected cognitive processes that require conceptual understanding, representation skills, and reflective thinking abilities.

At the problem-understanding stage, students demonstrate varying initial abilities depending on their understanding of the context. Some students are able to grasp the meaning of the question immediately, but others require additional stimulation to identify important information. This aligns with the findings (Kappassova et al., 2025); (Grei & Fischer, 2013) which emphasizes that success in mathematical literacy is greatly influenced by how students understand the realistic context given before entering the formulation stage. The problem understanding stage is an important foundation because errors at this stage often lead to errors in model formulation (Chen, 2022; Christiansen, 2007; Donmuş Kaya & Kükey, 2022; Haara, 2018; Kolar & Hodnik, 2021; Temur, 2012). The mathematical problem formulation stage is one of the most challenging parts. Students often experience confusion when having to transform narrative information into a valid mathematical model of the SPLDV, for example, defining variables and writing equations representing the relationships between quantities. This phenomenon is consistent with (Kappassova et al., 2025); (Aksu et al., 2022; Altun & Bozkurt, 2017; Bolstad, 2023; Harisman et al., 2023; Kozakli Ulger et al., 2022) who found that the formulating stage is one of the main weaknesses of students in mathematical literacy. This finding is also supported by (Iskandar et al., 2024) which states that students with a linguistic intelligence profile tend to be able to explain the context but are less accurate in formulating mathematical models, while students with logical intelligence are quicker to construct models but are less accurate in explaining the verbal context.

At the stage of using concepts, procedures, facts, and mathematical reasoning, most students are able to perform algebraic operations mechanically, but always understand the conceptual meaning behind the procedures they use. When students succeed in constructing the SPLDV model correctly, they can continue solving it using the substitution or elimination method. However, some of them make procedural errors such as subtracting signs or incorrect substitutions. (Muhaimin et al., 2024) stated that the ability to employ or apply concepts is an important indicator of mathematical literacy and many students are algorithmically capable, but do not fully understand the mathematical reasons behind the steps they take. The stage of interpreting, applying, and evaluating results requires a higher level of reflective ability. At this stage, students must check whether the obtained solution makes sense or is appropriate to the context. The students' who are strong in contextual reasoning can relate variable values to real world situations such as quantity of goods, prices, or other conditions and check the consistency of their answers. However, some students simply stop at the results without first verifying them. This is consistent with analysis (Kappassova et al., 2025) which found that the

interpretation stage is also a common difficulty point for students because it requires integration between mathematical knowledge and understanding of the context. The final stage, summarizing the results, shows significant variation in ability. The students with a deep understanding can convey conclusions clearly and structured according to the context of the problem. Meanwhile, students who are less reflective provide conclusions that simply repeat numerical results without explaining their contextual meaning (Bisaillon, 2023; Haara et al., 2021; Heyd-Metzuyanim et al., 2021; Jablonka, 2015; Kholid et al., 2022). (B et al., 2025) show that a systematic and experience based learning model such as the ELPSA framework can strengthen inference skills because it encourages students to communicate their work in a structured and reflective manner.

Overall, the findings of this study are consistent with several previous studies which state that the most difficult stages in mathematical literacy are formulating and interpreting contextual problems into mathematical models (Kappassova et al., 2025; Muhaimin et al., 2024; Altun & Bozkurt, 2017; Harisman et al., 2023; Kozakli Ulger et al., 2022; Herman et al., 2022). Similar findings were also reported by (Canbazoğlu & Tarim, 2020) and (Heyd-Metzuyanim et al., 2021), who explained that students tend to succeed in performing procedures but often fail to connect mathematical operations with real-life contexts. In addition, the findings of this study strengthen the results of (Bansilal & Debba, 2012) and (Temur, 2012), which emphasize that mathematical literacy is not merely computational ability but also the ability to reason, communicate, and evaluate mathematical solutions contextually. However, this study specifically highlights how students' contextual understanding and reflective thinking interact dynamically across all stages of the literacy process in SPLDV problems.

The similarities between this study and previous research may occur because mathematical literacy fundamentally requires students to integrate contextual understanding, mathematical representation, reasoning, and interpretation in solving problems. Therefore, students in different educational contexts often experience similar difficulties, especially in transforming narrative problems into mathematical equations and interpreting solutions contextually. Nevertheless, this study also demonstrates several differences from previous findings. Some earlier studies focused mainly on procedural errors or final achievement scores, whereas this study provides a more detailed exploration of the gradual cognitive processes experienced by students at each literacy stage. These differences may be influenced by variations in research methodology, learning environment, characteristics of SPLDV contextual problems, and differences in students' cognitive profiles and reflective thinking abilities. In addition, the integration of contextual reasoning analysis in this study allows a deeper understanding of how students evaluate the appropriateness of mathematical solutions in real-life situations.

This study contributes theoretically and practically to the field of mathematics education, particularly in understanding students' mathematical literacy processes in SPLDV learning. Theoretically, this research enriches the literature on mathematical literacy by demonstrating that literacy development occurs progressively through interconnected stages involving conceptual understanding, mathematical representation, procedural fluency, contextual reasoning, and reflective evaluation. Practically, the findings provide a framework for teachers to identify students' difficulties at specific literacy stages and design learning interventions accordingly. Furthermore, this study offers a new perspective that mathematical literacy assessment should not only focus on final answers but also on students' reasoning processes and their ability to connect mathematics with contextual situations.

Overall, this research shows that students' achievement at each stage of the mathematical literacy process is strongly influenced by the quality of their initial understanding, mathematical representation skills, and accuracy in interpreting context. This finding is consistent with global trends in mathematical literacy research, where the greatest challenges lie in the stages of transforming questions or problems into mathematical models and interpreting the results (Kappassova et al., 2025); (Muhaimin et al., 2024). Furthermore, variations in ability between students indicate the need for learning strategies that are adaptive to students' cognitive characteristics, as demonstrated (Iskandar et al., 2024). These results further reinforce

the notion that mathematical literacy is not merely the ability to calculate, but rather a gradual thinking process that can be enhanced through meaningful learning experiences (Afni & Hartono, 2020; Bansilal & Debba, 2012; Efriani et al., 2019; Temur, 2012). The findings of this study have important implications for mathematics learning practices, especially in designing contextual and reflective learning environments that support students' literacy development at every stage. Teachers are encouraged to provide learning activities that emphasize problem understanding, model construction, contextual interpretation, and reflective evaluation rather than merely procedural completion. Academically, this study can serve as a reference for further research related to mathematical literacy, contextual reasoning, and cognitive characteristics in mathematics learning. Future studies are recommended to explore mathematical literacy processes in different mathematical topics, educational levels, or learning models, as well as integrate qualitative and quantitative approaches to obtain more comprehensive findings.

CONCLUSION

Based on the research results, it can be concluded that mathematical literacy develops through five important stages, namely 1) understanding mathematical problems, 2) formulating mathematical problems, 3) using mathematical concepts, procedures, facts, and reasoning, 4) interpreting, applying, and evaluating the results of a mathematical process, and 5) concluding the results obtained accurately. The each stage requires different cognitive abilities and students' success in mathematical literacy is greatly influenced by how they pass through each stage. The analysis results show that two most challenging stages for students are formulating a mathematical model and interpreting a result, as confirmed by several studies that show these two stages are the main weakness in mathematical literacy. The students' ability to apply mathematical concepts and draw conclusions depends heavily on their initial understanding of the context and their ability to reflect. Therefore, a learning approach is needed that not only emphasizes solution procedures but also provides meaningful learning experiences that help students understand the context, build mathematical representations, and critically evaluate solutions. Experience based approaches and problem solving have been proven effective in helping students navigate all these stages better. The suggestions in this research are 1) strengthening the stage of formulating mathematical problems (formulate), namely modeling problems into mathematical models, 2) learning is designed based on context and experience/experiential such as the PEARL learning model, 3) teachers need to accustom students to verifying solutions and linking them back to the context or trigger questions, 4) teachers need to apply differentiated learning strategies, 5) development of assessments based on the literacy process, and 6) the five stages in the mathematical literacy process in this research need to be tested in a wider context such as different schools, different levels, or other mathematical topics to strengthen the validity and generalization of the stages in the mathematical literacy process.

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