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Problems of Students' Mathematical Literacy Reviewed from the Self-Regulated Learning of Vocational High School Students on Exponential Material

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ABSTRACT

Mathematical literacy is a crucial aspect of mathematics learning, yet it remains a significant challenge among students. While previous research has largely emphasized instructional approaches to enhance mathematical literacy, there is a lack of focus on the underlying difficulties faced by students, particularly in relation to self-regulated learning (SRL). This study aims to explore the problems in mathematical literacy encountered by vocational high school students at SMK Negeri 2 Bawang, Banjarnegara Regency, on exponential material, analyzed through their SRL levels. Employing a descriptive qualitative approach, the study involved three student subjects representing high, medium, and low SRL categories. Data collection was conducted using a mathematical literacy test, an SRL questionnaire, and interviews. The results indicate that variations in SRL levels significantly influence the types of difficulties students experience. Students with low SRL face extensive challenges, including understanding problem contexts, constructing mathematical models, and interpreting results. Those with medium SRL can comprehend the problems but struggle with selecting appropriate solution strategies and accurately representing contextual situations in mathematical forms. Meanwhile, students with high SRL exhibit systematic and reflective thinking yet encounter obstacles in connecting mathematical results to real-life contexts. These findings underscore the role of SRL in shaping students' mathematical literacy challenges. Further research is recommended to investigate additional internal factors affecting mathematical literacy to develop more adaptive and targeted instructional strategies.

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1. INTRODUCTION

In the era of globalization and the industrial revolution 4.0, mathematics education is not only required to convey basic concepts, but also to develop students' mathematical literacy skills. Mathematical literacy is a crucial aspect that reflects a person's ability to formulate, apply, and interpret mathematics in various real-life contexts [1]. This ability is closely related to 21st century competencies such as logical reasoning, representation, connections, communication, and mathematical problem solving [2]. Mathematical literacy is also needed to bridge abstract concepts in mathematics with their applications in the real world [3].

However, the mathematical literacy of Indonesian students still shows concerning results. Based on the 2018 Programme for International Student Assessment (PISA) report, Indonesia is ranked 73rd out of 79 countries with a mathematical literacy score that is still below the international average. Most students are only able to solve problems at a basic level, indicating limitations in the ability to understand, use, and reflect on mathematical concepts in everyday contexts [1]. This condition does not only occur in general, but is increasingly apparent in Vocational High School (SMK) students who are actually required to have applied mathematical skills to face the world of work.

The problem of students' mathematical literacy is not only related to solving mathematical problems procedurally, but is more complex, including the process of how students capture meaning from a context, transform information into a mathematical model, interpret results, and reflect on solving the problem. Many students have difficulty in identifying relevant information, choosing the right solution strategy, and connecting calculation results to real contexts [4]. This shows that mathematical literacy is a high-level thinking skill that requires simultaneous mastery of cognitive and metacognitive processes.

Unfortunately, the majority of previous research has focused more on improving mathematical literacy through certain learning models [5][6], without exploring in depth the roots of the difficulties or obstacles experienced by students in the process of learning mathematics. In fact, before determining an effective learning strategy, it is important to first identify the basic problems faced by students in their learning process.

Research by Anggraeni et al. [7] shows that learning difficulties in mathematics are caused by internal factors such as negative attitudes of students towards mathematics, low interest in learning, weak motivation, and lack of sensory abilities. Meanwhile, external factors include the less than optimal role of teachers, limited learning facilities, and minimal support from the family and community environment. One internal factor that is very relevant to the problem of mathematical literacy is the ability of self-regulated learning (SRL).

Self-Regulated Learningis the ability of students to manage their learning process independently, starting from planning, monitoring, to reflecting on learning activities. Students with low SRL tend not to have effective learning strategies, have difficulty in managing time and tasks, and are not used to evaluating mistakes [8]. As a result, they have difficulty understanding the context of the problem, constructing appropriate mathematical models, and drawing accurate conclusions—all of which are key components of mathematical literacy.

Burkhardt, Pead, and Stacey [9] emphasizes that mathematics learning should help students understand the relevance of mathematics in real life, not just memorizing procedures or formulas. Students' inability to connect mathematical concepts with real-world contexts reflects conceptual and contextual problems in mathematical literacy. This is in line with Cardoso Espinosa's view [4] which emphasizes that mathematical literacy is the foundation in forming quantitative thinking skills, including in representing information in the form of graphs, tables, and mathematical models needed in decision making. Furthermore, Solomon [10] highlights the importance of developing inclusive identities in mathematics learning. When students feel alienated from the process of learning mathematics, they tend to be less emotionally and cognitively engaged, which ultimately worsens their level of mathematical literacy.

Exponential material is one of the challenging topics for vocational high school students because it contains abstract and applicable concepts. In mathematical literacy questions, students are not only required to understand the formula, but also to be able to apply exponential concepts to real situations, such as population growth or depreciation of goods. Research shows that high SRL can help students manage learning strategies, understand important information, and formulate appropriate problem solving in an exponential context [8][11].

Based on the description, the gap in this research lies in the tendency of previous studies that focus more on improving mathematical literacy without specifically exploring the source of students' difficulties in understanding mathematics from the aspect of their learning process, especially those related to self-regulated learning. Therefore, this study is here to fill this gap by describing in depth the forms of mathematical literacy problems of vocational high school students based on the differences in SRL levels they have. With this approach, it is hoped that more precise and in-depth root problems can be found as a basis for designing contextual and personalized learning interventions.

2. METHODE

This study uses a qualitative approach with a descriptive design. This approach was chosen because it allows researchers to explore in depth the experiences, strategies, and thinking processes of students in dealing with mathematical literacy problems based on exponential material. The descriptive design used has also been applied in previous studies, such as research by Afrizal [8] which examines students' mathematical literacy from a self-regulated learning perspective.

The population of this study was all students in class X TE 5, totaling 36 students.SMK Negeri 2 Bawang, Banjarnegara Regency, which has studied exponential material in the mathematics curriculum. The sample was selected using a purposive sampling technique by considering variations in the level of self-regulated learning, namely students were grouped into three categories: high (T1), medium (S1), and low (R1) each 1 person. This approach has been used in the research of Rizqa et al. [12] to identify differences in mathematical literacy abilities based on the level of self-regulated learning.

The data in this study were collected through several instruments and techniques. The instrument used was a mathematical literacy test where there were mathematical questions developed with a mathematical literacy approach on exponential material used to measure problem solving abilities and the application of mathematical concepts. The indicators analyzed to see the problems of student literacy were: 1) Formulate, namely formulating real problems mathematically; (2) Employ, namely using mathematical concepts in solving problems; and (3) Interpret, namely reinterpreting mathematical results, solutions, or conclusions into the context of the problem [1].

Next is the Self-Regulated Learning (SRL) Questionnaire: This instrument is used to measure the level of student learning independence and group them into high, medium, and low SRL categories. This SRL questionnaire uses a Likert scale with a score of 1–4, which includes positive and negative statements. The scoring arrangement of the SRL scale items is presented in the following table:

Table 1. SRL scale item scoring structure

Answer Categories	**Positive**	**Negative**
Strongly Disagree (STS)	1	4
Disagree (TS)	2	3
Agree (S)	3	2
Strongly Agree (SS)	4	1

Source: Adapted from Azwar [8]

To determine the category of Self-Regulated Learning (SRL) of these students, the positive and negative scores obtained are analyzed based on the intervals that have been set. The range of positive and negative scores is calculated using the maximum and minimum data ranges. Furthermore, the difference between positive and negative scores is used as the main indicator to determine the category of SRL of students. The categories are divided into three, namely high, medium and low [13].

Next, the data collection technique is through In-depth Interviews. Interviews are conducted to explore in detail the problem-solving strategies, obstacles faced, and students' thinking processes. These data collection techniques have proven effective in studies examining mathematical literacy and Self-Regulated Learning [8].

Data analysis in this study was conducted using a qualitative descriptive approach through several systematic stages. Qualitative data analysis is a systematic process involving data reduction, data presentation, and drawing conclusions, using the four identified analysis techniques to produce meaningful findings and a comprehensive understanding of the research phenomenon [14]. The first stage is data reduction, where data obtained from questionnaires, tests and interviews are filtered and grouped based on their relevance to mathematical literacy indicators and students' Self- Regulated Learning (SRL) levels. Furthermore, the reduced data is presented systematically in the form of a narrative identifying the problematic patterns that emerge. The researcher then interprets the data and links it to the theory of mathematical literacy, formulates the main problems of students in the process of mathematical literacy of students on exponential material, and develops recommendations to overcome the problems. After the data is presented, the next step is drawing conclusions which is carried out through a triangulation process, namely by comparing data obtained from various data collection methods (tests and interviews).

In addition, the principles of developing mathematical literacy proposed by Cardoso Espinosa [4] also forms the basis of this research, especially regarding the importance of technology integration and innovative learning strategies in improving students' mathematical literacy.

The following are questions about students' mathematical literacy skills on exponential material:

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A workshop produces certain components of a Motorcycle. On the first day (day 0), the workshop
successfully produces 10 components. It turns out that every day the number of components produced increases exponentially with a growth factor a (with a>1).

The exponential function is expressed as:
$f(x) = P0 \bullet \alpha^x$ Where :

- F (x) = number of components produced on day x
- α = daily growth factor (where a>1)
- x = number of days after the first day.

Question :

a) Explain how you would construct a mathematical model to describe the growth of component production in this workshop? Explain why α >1?

b) Suppose α = 1.2 (meaning a 20% increase every day). Use the formula $f(x) = 10 \bullet (1.2)^x$ to calculate how many components are produced on the 5th day. Show your calculation steps clearly.

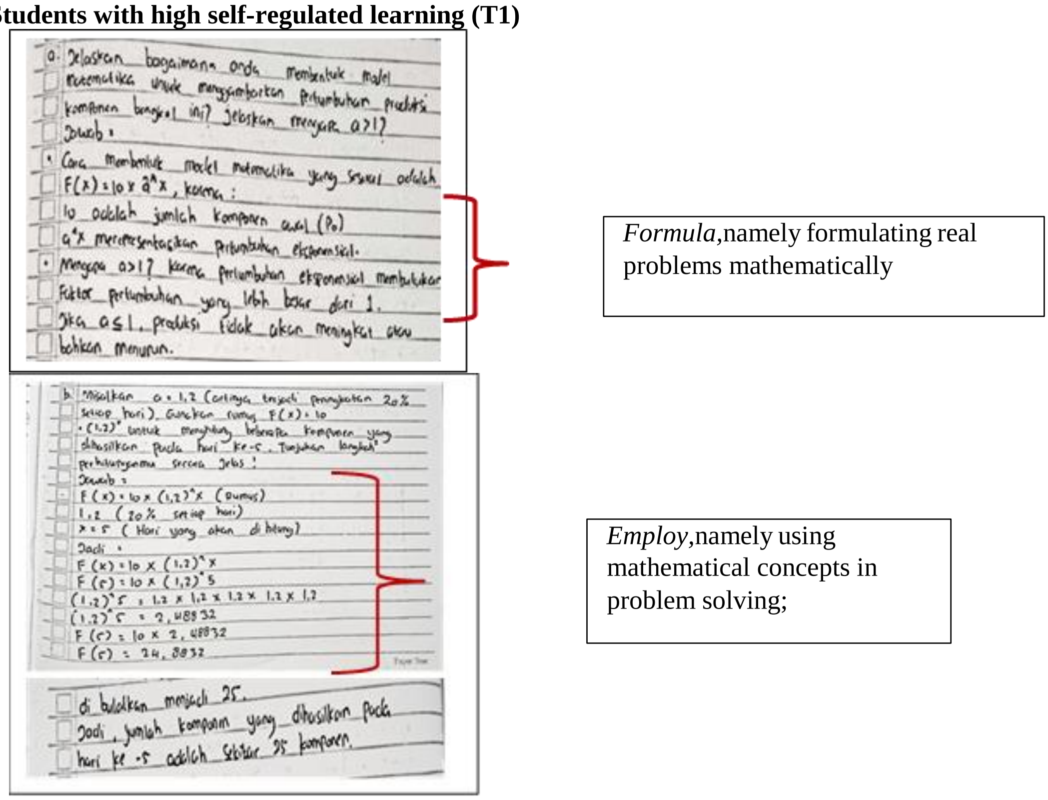
Based on your calculation results, draw a graph of the growth in production volume over 7 days and explain the growth pattern seen based on the graph.

3. RESULTS AND DISCUSSION

3.1 Result

This study aims to describe the forms of students' mathematical literacy problems based on high, medium, and low self-regulated learning (SRL) categories. Each student category is analyzed based on the results of mathematical literacy tests and in-depth interviews, especially on the indicators of formulating, applying, and interpreting in the context of exponential material.

a. Students with high self-regulated learning (T1)



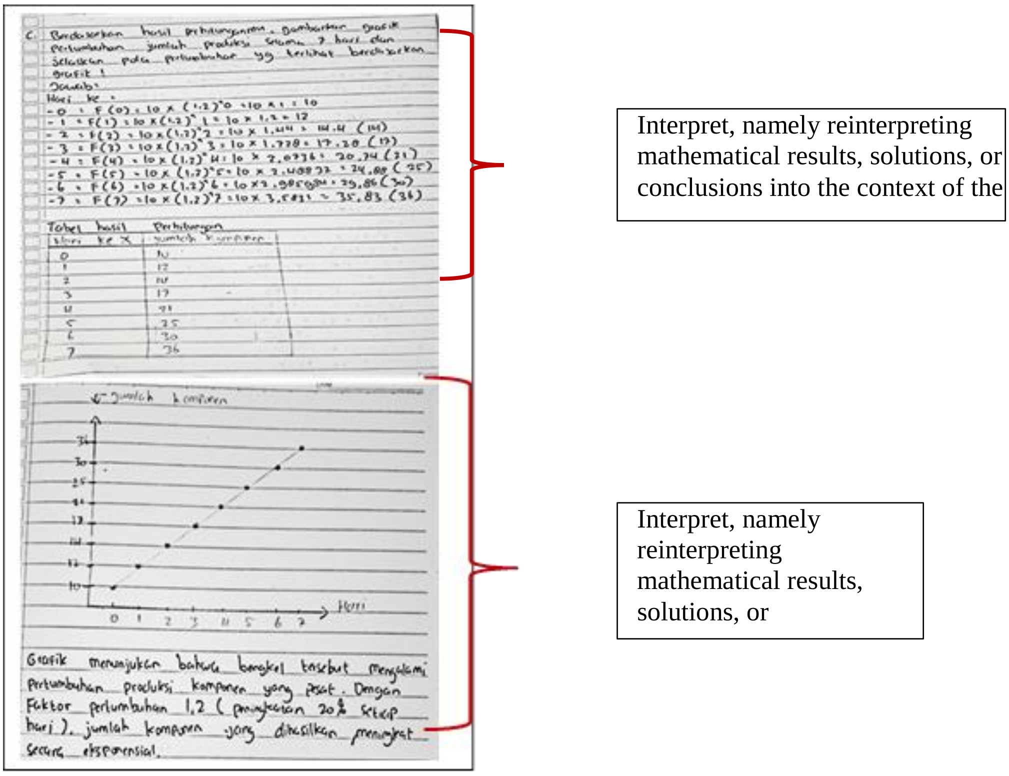


Figure 1. Subject T1's Answer

Based on Figure 1, the mathematical literacy process of students with high Self Regulated Learning, students do not experience problems in formulating problems. This is shown through the preparation of accurate mathematical models and clear reasons for choosing exponential models, such as the growth factor a>1 which is relevant to the context of the problem. In terms of applying the concept (employ), students also do not show any obstacles in writing exponential formulas to calculate the number of components on the 5th day in detail and systematically, including in the process of calculating numbers.

In the interpreting and communicating indicator, students have no difficulty in describing the growth graph of the number of components accurately and explaining the exponential growth pattern descriptively. However, the problem that appears is that students do not create the right scale in visualizing the graph so that the graph points look rather linear even though they are exponential.

Based on the interview results, student T1 also did not show any problems in solving exponential problems. The interview results showed that student T1 had a systematic approach in solving exponential problems. At the stage of formulating the problem, students stated that they had no difficulty in understanding the context of the problem and could identify important elements, such as the daily growth factor (a) and its relationship to changes in the number of component production each day. Students also showed how to integrate the information in the problem with relevant mathematical concepts, and explained the relationship between the parameter a>1 and exponential growth in a real context without any difficulty. The following is a transcript of the interview with T1.

Researcher : *"Tell me what was the first thing you did when you read the question?"*

Subject : *"I read the question carefully to understand what was asked. I noticed that the question asked to calculate the amount of production on a certain day using the exponential formula. Then, I noted down important information such as the initial value of production and the daily growth factor, ma'am.*

In applying the conceptual aspect (employ), students do not experience difficulties in applying the exponential growth formula $f(x)=P0 \cdot a^x$, students can calculate the production value on the 5th day carefully, and ensure the accuracy of the results through rechecking. Students can also visualize data well through clear graphs, and explain changes in value quantitatively and qualitatively. This is shown during the interview.

Researcher : *"Once you understand the problem, what steps do you take to solve it?"*

Subject : *"I start by plugging the known values into the formula. For example, on day 5, I replace x with 5 and calculate the result. After that, I also draw a graph based on the calculation results to visualize the production growth."*

In the aspect of interpreting and communicating (interpret), students are able to provide comprehensive explanations related to the calculation results, such as how the value of a affects the growth of production volume and the relevance of exponential patterns to the real situation presented in the problem. Students not only conclude that production increases steadily, but are also able to connect the calculation results with graphs, showing in-depth analysis of growth patterns. This is demonstrated during the interview.

Researcher : *"Do you have difficulty calculating or drawing graphs? How do you overcome it?"*
Subject : *"Not really, ma'am. If I have any difficulties, I usually double-check the results with a calculator and see if the results match. For graphs, I make sure that the scale and values I use match the data in question."*

From the interviews and the results of the students' answers, it was identified that students with high Self-Regulated Learning did not have difficulty with mathematical literacy in answering exponential problems. However, the findings in this study, students with high Self-Regulated Learning had the main problem located at the graphic representation stage, especially in the aspects of scale accuracy and visual interpretation of mathematical models. Students were able to use effective learning strategies, including reflection on the steps taken and the ability to elaborate mathematical concepts independently. This shows that students not only master procedural skills, but also understand concepts and can apply them in various contexts meaningfully.

b. Students with moderate self-regulated learning (S1)

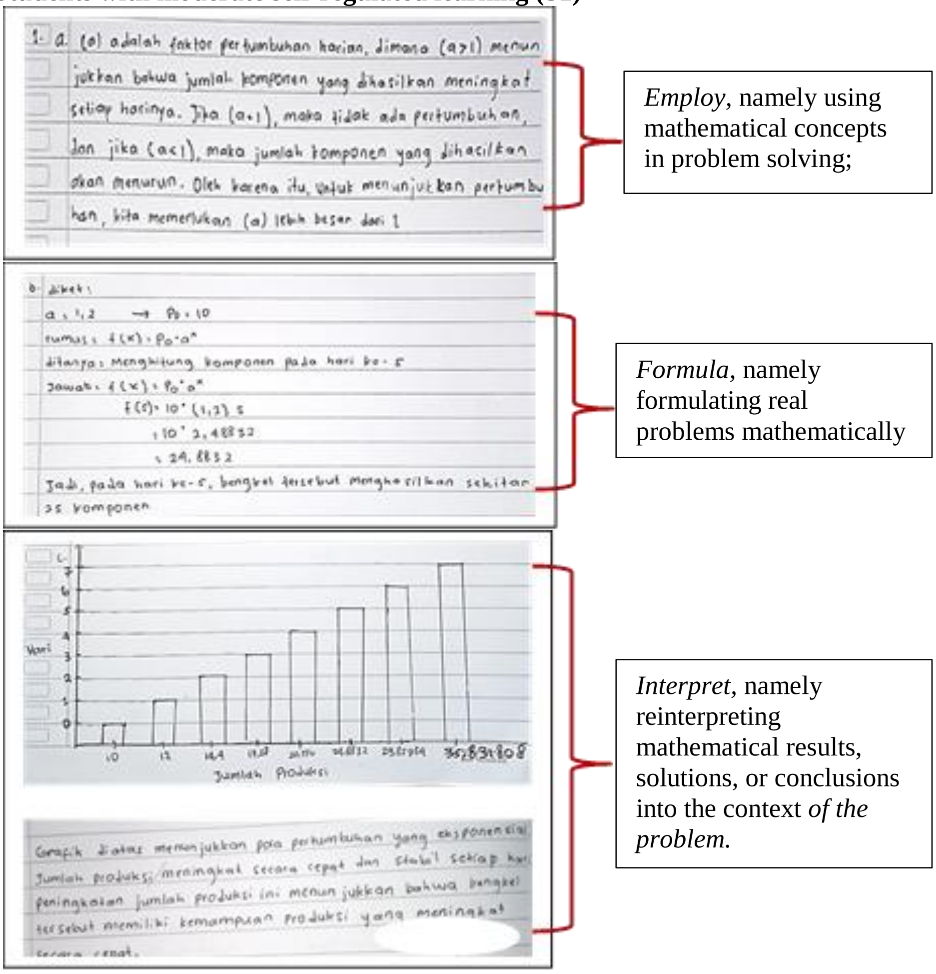


Figure 2. Subject S1's Answer

Based on the answers of students in the S1 category, there are several problems in the mathematical literacy process that can be seen in each indicator. In the aspect of formulating problems, students do not seem to have difficulty in being able to verbally explain the growth factor a, such as a>1 for growth, a=1 for stagnation, and a<1 for decline.

However, this explanation is not deeply connected to the mathematical model $f(x)=P0.\cdot a^x$ where in the question students are asked to explain how to form a mathematical model to describe the growth of component production in the workshop, but students do not explain it, so students do not fully utilize the information in the question to build a stronger mathematical representation.

In the aspect of applying the concept (employ), students can write down the concept and do not experience difficulties in using the given formula correctly, students can calculate the value of f(5)=24, and describe the exponential growth graph correctly. However, students seem to only focus on the calculation procedure without providing validation of the results or explaining how the numbers are relevant in the context of the problem where the problem requires students to show the calculation steps clearly.

Furthermore, in the aspect of interpreting and communicating (interpret), students successfully concluded that the amount of production on the 5th day was around 25 components and described the graph with a bar chart as a stable exponential growth pattern. However, even though students have shown the correct calculations and presentation of data in the form of graphs, problems arise in the aspect of visual interpretation and reinterpretation of mathematical results into the context of the problem.

Students choose to use a bar chart to represent the amount of production over seven days, but the graph presented does not fully reflect the characteristics of exponential growth accurately. This is evident from the use of a horizontal axis that does not follow the convention of a time-to- production growth bar chart, the horizontal axis should be filled by day 1, day 2, and so on and the vertical axis filled with production value. In addition, the graph is depicted with a scale range that appears inappropriate and disproportionate to the student's calculation data, as a result the exponential growth visual becomes dull, or even looks like it is rising slowly and steadily when in fact it should be increasing faster.

Then the student's written interpretation states that the growth occurs "fast and steady every day," which is less in accordance with the true exponential nature, where growth occurs increasingly quickly and is not linear. This indicates that although the student understands that there is an increase in production, he has not been fully able to critically interpret the exponential pattern or relate the graph and calculations back to the context of the problem as a whole. Thus, the main problem lies in the student's limitations in communicating mathematical information into accurate visual representations and contextual narratives.

Based on interviews with students who have a moderate level of Self-Regulated Learning, it is seen that students have quite good efforts in understanding exponent problems, but are not yet optimal in managing their learning strategies and mathematical literacy. In the problem formulation stage, students need more time to understand the context of the problem, especially in identifying important information such as initial values and growth factors. This is shown during the interview.

Researcher :*"What was the first thing you did when you saw the question?*

Subject :*"First, I read the problem, but it was a bit confusing to understand all the information. So, I tried to find what was important, like the starting number or the growth factor, but it took me some time to decide."*

When applying the concept of exponents, students are able to use relevant mathematical formulas, although the steps are sometimes less systematic. This can be seen from the students' answers during the interview.

Researcher :*"Once you understand the problem, how do you determine the steps to solve it?"*

Subject :*"I immediately used the formula f(x)=P0·ax that has been taught. But, sometimes I forget to check whether the numbers are correct or not, so I recalculate several times to make sure."*

Students also showed particular difficulties when entering values into formulas, as expressed in their statements.

Subject :*"Sometimes I'm confused about what position x represents, so I try it out until the result is right."*

At the stage of interpreting and communicating results, students can explain part of the process but not in depth.

Researcher :*"What about the graph you made? What were your steps in drawing it?"*

Subject :*"I made a graph based on the calculation results only. However, I only plotted a few important points, such as day 1 and day 5. I didn't pay much attention to the overall shape of the graph."*

Researcher :*"From the graph you created, what can you conclude about the exponential growth pattern?"*

Subject :*"The graph shows a steady increase in growth, but I don't really understand why it is like that. Maybe because the growth factor is more than 1."*

Students also showed that the process of evaluating their work was not yet fully optimal.
When the researcher asked,

Researcher :*"How do you evaluate the results of your work? Do you feel confident with your answers?"*

Subject :*"I usually see if the end result makes sense, but sometimes I forget to check the process in detail. If I have more time, I like to ask a friend to make sure."*

Overall, the main problems experienced by students with moderate Self-Regulated Learning include difficulties in understanding the meaning of context, inaccuracy and imprecision in constructing graphs, and limitations in explaining mathematical relationships descriptively. Although students already have the awareness to solve problems independently, suboptimal self- regulation has an impact on their ability to integrate mathematical understanding, strategies, and communication as a whole. This reinforces that mathematical literacy does not only rely on procedural knowledge, but requires integrated reflective, representative, and communicative thinking skills.

c. Students with Low Self Regulated Learning (R1)

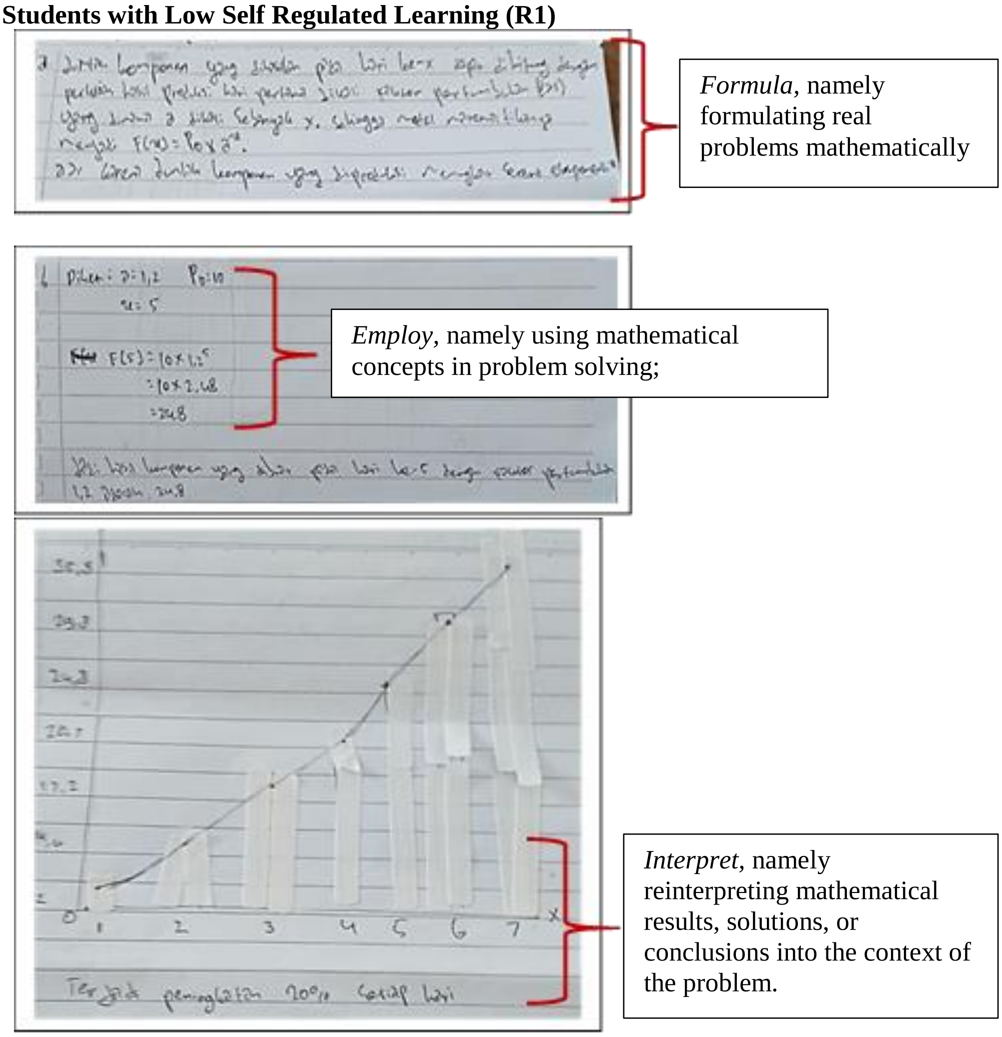


Figure 3. Student R1's Answer

Based on the results of students' work that are included in the low Self-Regulated Learning category, there are a number of problems in mathematical literacy skills. In the formula aspect, students have indeed mentioned basic parameters such as the initial value of production ($P0=10$) and growth factors ($a=1{,}2$), and tried to determine the number of components on the 5th day. However, students were unable to formulate a mathematical model in a complete and contextual manner. Model(x) = $10 \cdot (1{,}2)^{X}$ used without any explanation regarding the reasons for its selection or its relevance to the context of the motorcycle component production problem. This shows that students have not been able to relate real situations to mathematical models in a meaningful way.

In the aspect of applying the concept (employ), students use the given exponential formula and calculate the value of f(5) = 24. Students also appear to have a fairly good procedural understanding in calculating the value of the exponential function from day 1 to day 7. However, striking problems are seen in the application of the concept to the form of a graph. The graph drawn appears disproportionate and inaccurate, both in terms of scale and placement of data points. As a result, the graph that should show exponential growth actually appears almost linear. Furthermore, although students write that there is an increase of "20% every day", which corresponds to the growth factor value of 1.2, there is no further explanation regarding how this information reflects the overall exponential growth pattern. This indicates limitations in understanding the concept of growth ratio and connecting it visually and verbally.

Furthermore, in the aspect of interpreting and communicating results (interpret), students do not provide meaningful explanations of the mathematical results obtained. The written explanation is limited to one short sentence that is not yet able to express the relationship between mathematical results and the real context in the problem. There is no attempt to explain the impact of growth on production activities in the workshop, or how the growth pattern can be used for planning purposes. In addition, there is no reflection on the suitability of the graph with the calculation or the possibility of inaccuracy in the visualization.

Based on interviews with students, it appears that they still need more time to understand the context of the problem and identify important information such as initial values and growth factors. This indicates that students need a more systematic strategy in understanding the problem. The following is a transcript of the interview between the researcher and subject R1.

Researcher :"What was the first thing you did when you saw the question?"
Subject :"I read the questions first, but sometimes I'm confused about which information is important. So I try to find the initial numbers and growth factors, but it takes time to be sure."

In applying the exponential concept, students are able to use the appropriate formula but are not yet fully systematic in the solution steps.

Researcher :"After understanding the problem, how do you determine the steps to solve it?"
Subject :"I immediately used the formula $f(x) = P_0.aX$ that was taught, but sometimes I forget to check whether the numbers I use are correct. So I recalculate to make sure."

In addition, students experienced confusion in placing the value of x in the formula, which caused them to try several approaches before finding the appropriate answer.

In the aspect of interpreting and communicating results, students can explain most of the process but not in depth.

Researcher :"What about the graph you made? What are the steps in drawing it?"
Subject :"I plot important points, like day 1 and day 5, but don't pay much attention to the overall shape of the graph."
Researcher :"From the graph you created, what can you conclude about the exponential growth pattern?"
Subject :"The graph keeps going up, but I don't really understand why it looks like that. Maybe because the growth factor is more than 1."

Students also indicated that the process of evaluating their work was not yet fully optimal.

Researcher :"How do you evaluate your answers? Are you confident with the results you get?", the student answered, "I usually see if the final result makes sense, but rarely check the process in detail. If I have more time, I like to ask my friends to make sure."

Overall, the problem of mathematical literacy of students with low SRL levels lies not only in the procedural aspect, but more in the inability to understand, represent, and communicate mathematical concepts contextually.

3.2 Discussion

Based on the results of the analysis of the research data above, it is known that students with high self-regulated learning (SRL) category do not experience significant difficulties in understanding the context of the questions, formulating problems, determining solution strategies, and interpreting the results logically and relevant to real life. This shows that students with high self-regulation abilities tend to be able to manage their learning process independently from planning, implementing, to evaluating learning outcomes so that their mathematical literacy process tends to be better. This finding is in line with the theory put forward by Zimmerman (2002), which states that SRL includes metacognitive, motivational, and strategic behavioral processes that interact with each other to support academic success. In the context of mathematics learning, this ability has an impact on students' success in understanding concepts and relating them to everyday life situations.

Meanwhile, students with moderate SRL category still show some obstacles, especially in understanding contextual problems and choosing the right solution strategy. Their thinking process tends to be partial, and the ability to control and reflect on the solution steps is still limited. Santika and Khoimah (2023) stated that students often experience obstacles in solving PISA-style problems, especially at the problem formulation and interpretation stage. This difficulty is related to a lack of understanding of the contextual information presented and the inability to choose the appropriate solution strategy. Furthermore, they emphasized that the level of mathematical literacy is greatly influenced by students' ability to organize and direct their learning process independently, especially when faced with problems that require contextual understanding.

Similar findings were also expressed by Mahajani et al [15]and Erli Rahmayanti et al. [16], which states that students' mathematical literacy skills are greatly influenced by their level of learning independence. Students with low levels of independence are only able to identify problems and draw simple conclusions, but have difficulty in developing appropriate solution strategies. In contrast, students with high learning independence show mastery of all indicators of mathematical literacy, including in solving context-based HOTS problems. This shows that mastery of mathematical literacy does not only depend on cognitive abilities, but is also greatly influenced by affective and metacognitive aspects such as learning independence and self-regulation. In the context of 21st century learning, these abilities are important to help students understand mathematical concepts and apply them in real-life situations meaningfully [15][16].

Meanwhile, students with low SRL category showed difficulties in almost all stages of the mathematical literacy process, starting from understanding the context of the problem, formulating the problem, to interpreting the results. Students in this category tend to be passive, do not show initiative in the learning process, and are less reflective about the mistakes made. This finding is in line with research conducted by Nurvicalesti [17], which states that students with low SRL levels have limited mastery of mathematical literacy indicators. They have difficulty in solving verbal problems and are unable to understand the purpose of the problems presented. In addition, students with low SRL are also generally unable to find or utilize relevant learning resources, which ultimately further hinders their ability to solve context-based problems optimally.

These facts further strengthen that the ability to organize, monitor, and evaluate the learning process is one of the important indicators in improving students' mathematical literacy. With good SRL skills, students can independently understand the context of the problem, identify important information, and apply the right strategy in solving mathematical problems, including exponential material that requires deep understanding and relevance to real-life situations.

Based on these findings, researchers recommend learning intervention strategies that focus on strengthening self-regulated learning (SRL). One effective strategy is the application of the problem-based learning (PBL) approach, as supported by the findings of Dewi Friska et al. [18]. This approach not only helps students develop learning independence, but also has a direct impact on improving mathematical literacy. With structured learning based on real problems, and supported by strong SRL, students will be better able to understand, process, and communicate mathematical information in various contexts, so they can solve problems more effectively and meaningfully.

4. CONCLUSION

This study confirms that Self-Regulated Learning (SRL) has a significant role in helping vocational high school students overcome various obstacles in the process of mathematical literacy, especially in solving problems on exponential material. Students who have high SRL abilities tend to be more independent in organizing learning strategies, understanding concepts in depth, and evaluating and reflecting on their learning process. This makes them more prepared and capable of facing problems that require high-level mathematical thinking skills. The results of the study showed that students with high SRL were more effective in solving exponential problems compared to students with low SRL.

However, this study still has limitations, namely the absence of direct intervention in the form of implementing a specific learning model aimed at improving students' SRL abilities systematically. Therefore, this is an important opportunity for further research to explore the effectiveness of learning approaches that can encourage increased SRL, such as through problem- based learning (PBL) strategies, the use of interactive e-modules, or the integration of contextual learning. Based on these findings, it is recommended that educators in vocational schools actively implement learning strategies that support strengthening SRL, especially in mathematics learning on exponential topics. In addition, further research is also needed to identify other factors that influence the success of SRL in improving students' mathematical literacy skills more comprehensively.

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