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INVESTIGATING LEARNING OBSTACLES IN MATHEMATICAL LITERACY: A STUDY ON LINEAR EQUATIONS WITH ONE VARIABLE

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ABSTRACT

The topic of linear equations with one variable is studied at the junior high school level. This topic is essential as it can be applied to solve various real-life problems. However, many students struggle to master this concept, often due to various learning obstacles. This study aims to describe the learning obstacles faced by students in understanding linear equations with one variable in the context of mathematical literacy. The method of research used is a descriptive method with a qualitative approach. The research subjects were six eighth-grade students from a junior high school in Bandung. Data were collected through written tests and interviews. The results revealed five types of learning obstacles related to the material of linear equations with one variable based on mathematical literacy. These obstacles include: difficulties in forming equations, inaccuracy in reading or understanding questions, and challenges in concluding. Additionally, students faced difficulties in understanding the relationships between different concepts and in understanding what needs to be done. To overcome these learning obstacles, several efforts can be made, including transforming abstract concepts into concrete and visual representations, improving interactive and contextual problem-based teaching methods, and offering varied exercises. These strategies are expected to significantly enhance students' mathematical literacy and reduce learning obstacles.

Keywords: Learning Obstacles, Linear Equations With One Variable, Mathematical Literacy.

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PRELIMINARY

Learning obstacles are a critical aspect to investigate in the context of mathematics education, as they can significantly impact students' learning outcomes. Understanding these obstacles is essential for improving the quality of teaching and learning processes. Therefore, the specific research question addressed in this study is: *What are the learning obstacles faced by students in understanding linear equations with one variable in the context of mathematical literacy?* In addition, this research aims to identify strategies for overcoming these obstacles and improving student learning outcomes.

According to (Suryadi, 2019), the ideal learning process for students in mathematics closely resembles the process undertaken by mathematicians, with the main difference being that students are not discovering new concepts but are instead engaged in re-personalization and recontextualization of existing knowledge. Sulastri and Arhasy, (2017) explain that this process may involve obstacles similar to those encountered by mathematicians when conceptualizing new ideas, which students also face.

Learning obstacles, as defined by Utami, Prabawanto, and Priatna (2022), are conditions that prevent students from acquiring new knowledge during the learning process, which may lead to difficulties in understanding and mastering the material. Further, Muthmainah, Fuadiah and Fitriasari (2021) Explains that learning obstacles are barriers encountered by students during the learning process that result in suboptimal outcomes. Given the importance of overcoming these obstacles, it is essential to examine and address the factors that contribute to these difficulties to ensure more effective mathematics instruction. By identifying and understanding learning obstacles, educators can create more targeted strategies to support students in overcoming challenges and achieving better learning outcomes in mathematics.

Learning obstacles can occur across all topics in mathematics education, one of which is the material on linear equations with one variable. A study conducted by Restianingsih and Pujiastuti (2020) showed that the difficulties students face in solving word problems involving linear equations with one variable include challenges in understanding concepts, facts, principles, and skills. Additionally, research by Rayhan and Sudihartinih (2022) Identified several difficulties faced by participants, namely: 1) lack of understanding regarding the form of mathematical models, 2) difficulty in performing multiplication, addition, and subtraction operations, and 3) difficulty in comprehending the information presented in the problems.

Linear equations with one variable are an essential foundation in algebra. Nafii (2017) states that linear equations with one variable are a very important topic for students to understand before they can grasp more advanced algebra concepts. This topic is also critical in the context of mathematical literacy, which is evaluated in international assessments like PISA 2021, as shown in the figure below.

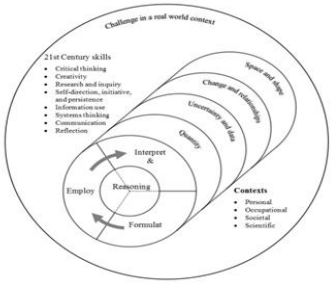

Figure 1. Mathematical Literacy by PISA 2021

Based on Figure 1, PISA 2021 Mathematical Literacy connects mathematical reasoning, problem-solving, mathematical content, context, and 21st-century skills. The mathematical content categories in PISA 2021 include four areas, one of which is "Change and Relationship," which pertains to algebraic material such as algebraic expressions, equations and inequalities, tables and representations in the form of tables and graphs, functions, modeling, and interpreting cha(Suryadi, 2019), the ideal lea. According to Sari (2015), mathematical literacy is the individual's capacity to formulate, use, and interpret mathematics in various contexts. In this regard, Umbara and Suryadi (2019) emphasize that a crucial element in the process of mathematical literacy is the internalization of mathematical concepts and the externalization of context, both of which are vital in solving mathematical problems. Moreover, Oktaviyanthi, Agus, and Supriani (2017) propose three indicators of mathematical literacy: the ability to formulate and interpret mathematics in various contexts, the involvement of mathematical reasoning, and the use of concepts, procedures, facts, and mathematical tools to describe a phenomenon. They also highlight the ability to apply mathematics in everyday life as a form of constructive and reflective citizenship contribution.

Despite the recognition of mathematical literacy's importance, limited research exists on learning obstacles related to algebraic topics, particularly within the context of "Change and Relationship". Rayhan and Juandi (2023) noted this gap and emphasized the need for further research into the learning obstacles associated with algebraic content. This study addresses that gap by investigating the learning obstacles students face when learning linear equations with one variable in relation to mathematical literacy. Understanding these obstacles is crucial for designing effective teaching strategies that will help students overcome difficulties and improve their mastery of the material (Maharani et al., 2022).

This research is expected to contribute to the development of instructional strategies that enhance students' mathematical literacy, helping to improve both their

performance in algebra and their overall ability to apply mathematics in real-life contexts. Additionally, the findings will provide valuable insights for future research and the design of effective didactic approaches to address learning obstacles in the study of linear equations with one variable, ultimately improving students' performance in assessments like PISA.

METHODS

This study employs a qualitative approach with a descriptive method. According to Sugiyono (2017), the descriptive method is used to depict, describe, and present an event related to the research object based on the situation and conditions at the time the research is conducted. This study aims to analyze data by describing or illustrating the learning obstacles experienced by students in solving problems related to linear equations with one variable, particularly those associated with mathematical literacy.

The participants in this study were six seventh-grade students from a junior high school in the city of Bandung. Three of the participants (P1, P2, and P3) were female, and the other three (P4, P5, and P6) were male. The small sample size was chosen to allow a more in-depth investigation of each student's learning obstacles. Although the sample size is limited, these six participants were selected because their responses represent those of other students.

Data were collected through written tests and interviews. The test instruments were developed to align with the PISA 2021 framework, specifically targeting the three key mathematical literacy processes: formulate, employ, and interpret. The questions were designed to assess students' ability to formulate mathematical problems, apply mathematical concepts to solve them, and interpret results in various real-life contexts. To ensure validity, the test items were reviewed by experts in the field of mathematics education. The written test was administered for approximately 60 minutes for each participant. Interviews were conducted after reviewing the respondents' answers, and these interviews were flexible, depending on the errors and thought processes of the six respondents regarding the questions. By comparing the results of the written tests and interviews, the researcher can gain a better understanding of the difficulties students face in learning linear equations with one variable. This descriptive analysis helps identify the obstacles that emerge, which are then explained through relevant literature on mathematical literacy and learning barriers.

RESULT AND DISCUSSION

Based on the answers and interview results from each participant, the following data were obtained.

Question 1

Question 1 is a linear equation with one variable, set in an occupational context, where this category is related to jobs. The problem in Question 1 includes three stages of PISA mathematical literacy: formulating in part a), applying in part b), and interpreting in part c).

1. *Dito is planning to open a coffee shop. He buys coffee beans for 37,000 per kilogram using three 100,000 rupiah bills. He receives 4,000 rupiah in change.*
   a. *Express this problem as an equation.*
   b. *Determine the weight of the coffee beans purchased in kilograms.*
   c. *Dito wants to buy an additional 2 kilograms of coffee beans. How much money is required to pay for the additional purchase?*

In part 1a), students are asked to express the problem in the form of an equation, based on the information provided in the question. In this problem, students are required to create an equation that can be used to determine the weight of the coffee beans purchased. Of the six participants who attempted the instrument, only two participants successfully formed the equation correctly, while the other four participants formed incorrect equations. An example of a student's incorrect equation is illustrated in Figure 2.

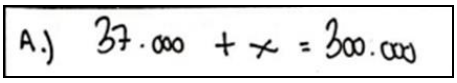

Figure 2. Answer for Question 1a) from Participant P3

Based on Figure 2, it is known that Participant P3 wrote an incorrect equation. During the interview, the participants admitted to being confused by the answers they had written and indicated that they had not fully understood the basic concept of equations. Below are the results of the interview conducted with P3.

Researcher: How did you form an equation from the problem in question 1a?

P3 : Well, my teacher said that an equation is one with an x in it. At first, I was confused about which x it was, so when I worked on it yesterday, I just wrote something random. I answered 37,000 + x = 4,000.

Researcher: Alright, what does x represent here? What is the value we are trying to find in this problem?

P3 : Hmm, x is the 300,000 rupiah, how much coffee was bought, ma'am?

Researcher: Why is the value of x 300,000 rupiah?

P3 : I don't know, ma'am.

Based on the interview results, P3 demonstrated a basic understanding of equations but was still confused about the value represented by *x*. P3 associated *x* with "300,000" without fully grasping its abstract meaning. This confusion highlights a broader difficulty, as students have not yet developed the necessary algebraic thinking skills to transform concrete problems into abstract algebraic representations. (Rohimah, 2017), explains that this challenge arises because there is no effective bridge to transition students from concrete to abstract thinking. Similarly, Wati and Murtiyasa (2016) found that errors made by junior high school students in solving PISA math problems often stem from limited reasoning abilities and a lack of creativity in translating real-world problems into algebraic forms. These findings underscore the importance of scaffolding techniques to guide students in developing both reasoning and algebraic thinking skills.

In part 1b), students are asked to determine the mathematical solution based on the information provided in the question. In this problem, students are required to determine the solution for the weight of the coffee beans purchased in kilograms. Of the six participants who attempted the instrument, five participants successfully found the correct solution, while one participant, P6, was unable to determine the solution correctly.

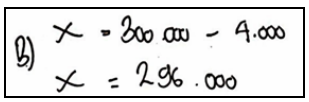

Figure 3. Answer for Question 1b) from Participant P6

Based on Figure 3, it is known that Participant P6 was unable to find the correct solution. During the interview, the student misunderstood the problem, which led to an incorrect strategy being used to solve the problem. This mistake resulted in an answer that did not match the expected outcome and showed a lack of understanding of the problem. Below are the results of the interview conducted with P6.

Researcher: How did you form an equation from the problem in question 1b?

P6 : For question 1b, I wrote x = 300,000 – 4,000, so the result is 296,000, meaning the value of x is 296,000, ma'am. The 300,000 is from the three 100,000 rupiah bills, and the 4,000 is the change.

Researcher: So, what does x = 296,000 represent?

P6 : The money for buying the coffee, ma'am.

Researcher: But the question asks for how many kilograms of coffee were bought, not how much money was spent on buying the coffee.

P6 : Oh, yes, ma'am. I thought it was like that, ma'am.

Based on the interview with P6, the student experienced difficulty understanding the question and mistakenly interpreted the value of x as the amount of money spent on buying the coffee, rather than the weight of the coffee beans requested. When the researcher reminded them that the goal was to find the weight, P6 realized the mistake. This highlights the need to strengthen students' understanding of reading and comprehending the context of the problem so they can solve it accurately. (Damayanti, 2022). This issue can be addressed through Polya's problem-solving framework, which offers a structured approach to understanding and solving mathematical problems. Polya's steps involve carefully reading and analyzing the problem, identifying what is being asked, defining variables for unknowns, and systematically developing a solution strategy (Mauliya, 2019).

In part 1c), students are asked to determine and evaluate the mathematical result based on the information provided in the question. In this problem, students are required to calculate the amount of money needed to pay for the additional coffee beans. Of the six participants who attempted the instrument, three participants successfully found the correct solution, while three participants provided incorrect answers, one of which was participant P2.

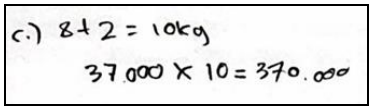

Figure 4. Answer for Question 1c) from Participant P2

Based on Figure 4, it is known that Participant P2 gave an incorrect answer. During the interview, the participant was not careful when reading the questions and assumed that they were only required to determine the amount of money needed. This mistake indicates a lack of attention to the details of the question, which affected the accuracy of the solution. Below are the results of the interview with P2.

Researcher: How did you solve question 1c?

P2 : For this one, we already know that 8 kg was bought previously, so adding 2 more kg makes it 10 kg. Then, multiplying by 37,000 gives 370,000.

Researcher: That's correct. So, how much money is needed to pay for the additional purchase?

P2 : 70,000, ma'am. I wasn't careful when reading the question, ma'am. I thought it was just asking to determine the amount of money needed.

Based on the interview with P2, the student was not careful when reading the question and assumed that they were only asked to determine the amount of money needed to buy the coffee. Although P2 correctly calculated the total weight of the coffee and multiplied it by the price per kilogram, they made a mistake in determining the amount of money required to pay for the additional purchase. This indicates a lack of attention to detail and understanding of the instructions in the problem. According to Maharani, Dasari, and Nurlaelah (2022), this obstacle arises from students' lack of preparedness in the technical aspects of learning, which leads to their failure to apply the correct steps. Polya's steps are again suggested as a way to address the issue by ensuring the student understands all aspects of the problem through careful, step-by-step problem-solving.

Question 2

Question 2 is a linear equation problem with a societal context, which is related to activities in society, whether local, national, or global. The problem in question number 2 includes three parts of the PISA literacy process: formulating in part a), applying in part b), and interpreting in part c).

2. *Rika will accompany her relative to the hajj dormitory, which is 80 km away from the meeting point. The group of hajj pilgrims has already left 30 minutes ago by bus. For some reason, Rika missed the group and plans to catch up by car. The bus travels 60 km per hour, and Rika's car travels 100 km per hour.*
    a. *Express the relationship between the quantities in the problem using an equation.*
    b. *Determine how long it will take for Rika to catch up with the group.*
    c. *If the distance from the meeting point to the hajj dormitory is 60 km, can the solution to part b be used?*

In part 2a), participants were asked to express the problem in the form of an equation based on the information provided in the question. In this problem, participants were required to create an equation that represents the relationship between the quantities in the question. Out of the six participants who tried the instrument, two participants successfully formed the inequality correctly, while the others formed an incorrect inequality, one of which was P5.

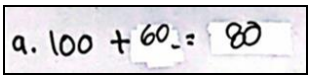

Figure 5. Answer for Question 2a) from Participant P5

Based on Figure 5, it is known that Participant P5 provided an incorrect answer. When interviewed, participant P5 admitted to improvising the answer because they did not know the formula that should have been used. Below is the result of the interview with P5:

Researcher: How did you solve the problem in question 2a?

P5 : I just made it up, ma'am, and plugged in the numbers from the question. I didn't know the formula, ma'am.

Based on the interview with P5, it is evident that the students did not know the correct formula to solve question 4a, so they improvised by inserting the numbers from the question without a clear understanding. This highlights a lack of conceptual understanding and skills in applying the necessary formulas to solve the problem. According Rayhan and Sudihartinih (2022), conceptual understanding is crucial in answering math problems; without a strong grasp of the concept, students will struggle to solve problems effectively. To address the limited understanding of the concept of linear equations with one variable, it is essential to broaden the scope of mathematical models taught. As suggested by (Jupri & Drijvers, 2016), instruction on equations should not be limited to forms like f(x) = c, but also include more complex forms such as f(x) = g(x), etc. This approach can enhance students' flexibility and understanding when dealing with various forms of linear equations.

In section 2b), participants were asked to determine the mathematical solution based on the information provided in the problem. In this case, the participants were required to calculate the time it would take for Rika to catch up with the group. Two out of six participants who attempted the instrument were able to find the correct solution, while the other four participants were unable to determine the correct solution, one of them being P1.

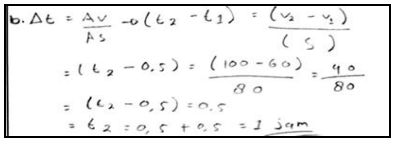

Figure 6. Answer for Question 2b) from Participant P1

Based on Figure 6, it is known that Participant P1 used the wrong formula to solve the problem, which resulted in an incorrect answer. This error indicates that the student has

not fully understood the concept and the proper application of the formula. Below are the results of the interview with Participant P1.

Researcher: How did you solve the problem in question 2b?

P1 : I used the delta formula, as far as I know, ma'am. So in that formula, $t_2 - t_1 = (v_2 - v_1) / s$. *$t_2$ is Rika's time, t_1 is the bus group's time, v_2 is the speed of Rika's car, v_1 is the speed of the bus group, and s is the distance, which is 80 km. Then I substituted the values, so* $(t_2 - 0.5) = (100 - 60) / 80$, *which simplifies to* $(t_2 - 0.5) = 40/80$, *so* $t_2 - 0.5 = 0.5$. *Therefore,* $t_2 = 0.5 + 0.5 = 1$ *hour, so Rika can catch up with the group in 1 hour, ma'am.*

Researcher: Okay. Where did you get this formula from?

P1 : I just knew it, ma'am, from what I remember, I think it's the delta formula like this.

Based on the interview with P1, the student used the incorrect delta formula to solve question 4b, resulting in an incorrect answer. Despite explaining the calculation steps in detail, the error in formula choice indicates a lack of understanding of the correct application. P1 admitted to using prior knowledge but did not fully grasp the problem's context. According to Fazzilah, Effendi, and Marlina (2020), students often make mistakes in selecting the correct formula due to a lack of mastery of prerequisite material, carelessness, and rushing to complete the task. To address difficulties in connecting previously learned concepts to new situations, problem-based learning (PBL) can be an effective approach. As noted by (Damayanti, 2022), implementing PBL trains students to relate scientific concepts to various real-world problems. This learning method encourages students to apply their prior knowledge in relevant contexts, enabling them to better understand and integrate concepts into real-life situations. By engaging in problem-based learning, students can develop stronger problem-solving skills and a deeper conceptual understanding.

In section 2c), participants are asked to determine and evaluate the mathematical result based on the information provided in the problem. In this case, participants are required to assess whether the equation from the previous part can still be used if the distance from the meeting point to the hajj dormitory is changed. One out of six participants who attempted the instrument provided the correct answer, while the other five participants gave incorrect answers, including participant P4.

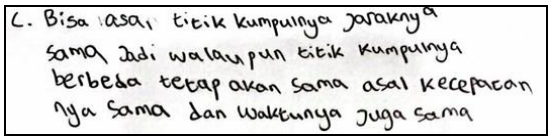

Figure 7. Answer for Question 2c) from Participant P4

Based on Figure 7, participant P4 demonstrated a misunderstanding of the problem, which led to the use of an incorrect approach and ultimately an incorrect answer. Additionally, participant P4 had not fully mastered the underlying concept. Here is the result of the interview with Participant P4.

Researcher: How did you solve the problem in question 2c?

P4 : Yes, ma'am. According to me, as long as the distance from the meeting point is the same, even if the meeting point changes, it will still be the same as long as the speed and time are the same.

Researcher: You mentioned that the distance from the meeting point is the same, even if the meeting point changes. What do you mean by that?

P4 : Yes, ma'am, the distance is the same in the problem. So even if the meeting point is changed, the distance remains the same.

Based on the interview with P4, the student demonstrated a misunderstanding of question 4b by stating that the same distance from the meeting point would lead to the same result, even if the meeting point changes, as long as the speed and time remain the same. P4's explanation indicates that they have not fully grasped the underlying concept of the problem, leading to an incorrect approach and inaccurate answer. This aligns with the view of Restianingsih and Pujiastuti (2020), who state that students who only memorize material without connecting concepts will face difficulties in both the learning process and the outcome. To address these difficulties, implementing conceptual learning strategies that emphasize the relationships between mathematical concepts can be beneficial.

Based on the results of the instrument test, it can be concluded that the participants experienced various learning obstacles. Five types of learning obstacles have been identified: difficulty in forming equations, errors in reading the problem, errors in concluding, difficulty in understanding the relationships between different concepts, and difficulty in understanding the steps necessary to solve the given test instrument.

Below is Table 1, which shows the learning obstacles experienced by each student. The obstacles are coded as follows:

- LO1: Difficulty or Mistake in forming equations
- LO2: Errors in reading or understanding the problem

- LO3: Errors in concluding
- LO4: Difficulty in understanding the interrelation of concepts
- LO5: Difficulty in understanding what needs to be done

Table 1. Learning obstacles experienced by each participant

	Question 1a	Question 1b	Question 1c	Question 2a	Question 2b	Question 2c
P1	None	None	None	LO1	LO4	LO3
P2	LO1	None	LO2	None	None	None
P3	LO1	None	LO2	LO1	LO5	LO4
P4	None	None	None	None	None	LO4
P5	LO1	None	None	LO1	LO5	LO5
P6	LO1	LO5	LO3	LO1	LO5	LO5

Based on the research findings, it can be concluded that no students successfully met all the mathematical literacy indicators. Sari (2015) states that individuals with strong mathematical literacy skills can achieve the three indicators necessary to solve mathematical problems. Therefore, students' mathematical literacy on the topic of linear equations in one variable is still considered low. The majority of respondents still face learning obstacles in converting problems into equations and understanding the steps required to solve them. This finding aligns with research by Kartika Dewi et al. (2020), which shows that the most common errors students make occur in the indicators of checking the correctness of problem-solving results and creating mathematical models for those problems. Additionally, research by Selan, Daniel, and Babys (2020) Also shows that, in the content of Change and Relationship, only a small number of students were able to achieve all mathematical literacy indicators, including identifying mathematical aspects, converting problems into mathematical models, using the model design to find solutions, and interpreting mathematical results in real-world contexts.

To overcome these learning obstacles, several efforts can be made, including transforming abstract concepts into concrete and visual representations. Priatna and Yuliardi (2018) suggests that simplifying students' understanding of abstract concepts can be achieved through concrete manipulation. Additionally, improving interactive and contextual problem-based teaching methods, as stated by Damayanti (2022), can help students link scientific concepts to everyday life problems. Offering varied exercises is also crucial, as emphasized by Sulastri and Arhasy (2017), who highlight the importance of variation in problems related to linear equations and inequalities to provide students with a

more diverse learning experience. These strategies are expected to significantly enhance students' mathematical literacy.

CONCLUSION

Based on the research findings, it can be concluded that there are five types of learning obstacles related to the topic of linear equations in one variable, as examined from the perspective of mathematical literacy. These obstacles include:

1. Learning obstacles in formulating equations: Students struggle to translate real-life problems into mathematical equations due to limited exposure and understanding of variable relationships. Addressing this involves using more diverse examples and complex equation forms.
2. Learning obstacles in reading or understanding the question accurately: Students often face challenges in comprehending the context or specific instructions within a problem, leading to ineffective problem-solving strategies. Encouraging students to carefully read and analyze the problem, identify key elements, and understand the relationships among variables can improve their ability to tackle questions accurately.
3. Learning obstacles in concluding: Some students fail to draw accurate conclusions because their approach relies on memorization rather than understanding. Providing problem-solving exercises that encourage them to apply concepts in various real-life contexts can help foster deeper comprehension and reasoning.
4. Learning obstacles in understanding the interrelation of concepts: Students lacking a strong conceptual foundation struggle to connect new and existing knowledge. Collaborative learning strategies, such as group discussions and peer problem-solving, can enhance their ability to integrate concepts and address misunderstandings effectively.
5. Learning obstacles in understanding what needs to be done: Difficulty in identifying the steps to solve a problem often stems from insufficient reasoning skills and unclear understanding of the required methods. Structured learning strategies that emphasize guided practice and provide step-by-step feedback can help students recognize and apply appropriate problem-solving strategies.

This study has several limitations, including a small sample size, which may not fully represent the broader student population. Additionally, the study focuses solely on linear equations with one variable, so the findings may not be generalizable to other mathematical topics. The use of written tests and interviews as data collection methods

also has limitations in capturing the full complexity of students' learning obstacles. Future research is recommended to involve a larger and more diverse sample and use various assessment methods to gain a more comprehensive understanding.

Further research is recommended to develop teaching approaches that address these specific obstacles. Effective methods may include integrating problem-solving techniques, incorporating teaching aids relevant to real-life scenarios, and fostering collaborative learning environments where students can share ideas and assist each other. By adopting such strategies, students' understanding of linear equations and their overall mathematical literacy can be significantly improved.

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