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Research Article

Analysis of Epistemological Obstacles on the Material of Two-variable Linear Equation System

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Abstract.
Learning barriers can impact teachers and students in achieving learning goals. One such obstacle is epistemological constraints which arise due to limited context provided for a new concept as it is studied for the first time. This study aims to describe students' epistemological obstacles in learning two-variable linear equation system (SPLDV) using a qualitative method and a phenomenological approach. It involves 12 eighth-grade students from Indonesian junior high schools. Data were collected using test methods, observation, and interviews. The validity of the data was established using the triangulation method, requiring the comparison of data with interviews. Data analysis techniques were carried out in three stages of data reduction, data presentation, and conclusions. The results showed four types of epistemological obstacles, namely obstacles in understanding equations, obstacles to algebraic arithmetic operations, barriers to understanding variables, and barriers to making mathematical models. These obstacles cause students difficulty in understanding SPLDV. Therefore, it is important for educators to pay special attention to understanding the basic concepts and requirements in studying SPLDV to help students overcome these obstacles.

Keywords: epistemological obstacles, mathematic education, two-variable linear equation system

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1. INTRODUCTION

Education is a place to prepare individuals to be productive, competitive, and positively influence members of society and education is closely related to knowledge. One of the essential human needs is education (1). According to Chotimah et al (2019) (2) Education is a process of interaction between a student and his teacher in formal education, informal education or even informal learning. Every organization, group, person or country can exist with education (3). Education in Indonesia includes all types of education held in this country, both those with formal and unstructured structures

(4). There are three main types of education in Indonesia, namely formal, non-formal and informal education (5). In Indonesia, the implementation of the national education system applies to all levels, pathways and types of education (6) . One of the existing educational initiatives is the mandatory 12-year education system, comprising six years of primary school, three years of middle school, and three years of high school.

In all stages of formal education in Indonesia, mathematics is a mandatory subject that students are required to study (7). One area that is very important in the development of science and technology is mathematics (8). Since ancient times, mathematics was considered difficult, giving rise to the perception among many people (9). The quality of learning mathematics in Indonesia has not yet reached an adequate standard, and is even in the low category; The performance of Indonesian students in global assessments like the Trends in International Mathematics and Science Study (TIMSS) and the Program for International Student Assessment (PISA) is viewed with significant concern due to low achievement levels in mathematics. (10). Adiwinata et al. (2018) It is said that in reality, there are still many problems related to learning mathematics, including one of which is the difficulties and obstacles experienced by students in understanding mathematical material.

Various challenges in the learning process arise from factors such as the disparity between the present learning approach and philosophical orientation, issues concerning the didactic design's impact on the learning flow, situations in teaching that deviate from the core of mathematics and the learning process, conceptual discrepancies among educators, students, and scientific concepts, the development of transpositional knowledge (both didactic and pedagogical), and diverse problems associated with didactical design. (11). Problems related to didactical design have ontological, didactic, and epistemological characteristics (Brousseau, 2002; Suryadi, 2019a) (11,12). Barriers at the ontological level emerge when there is a discrepancy between the instructional design requirements and the child's capacity. Didactic hindrances may occur as a result of the curriculum's sequence and stages, as well as how it is delivered in the classroom. Meanwhile, the restricted context employed in didactic design can give rise to epistemological constraints. Essentially, epistemological constraints indicate a disparity between the context of the learning encounter that has been undergone and the requirement to connect learning outcomes with various contexts beyond that experience. (Suryadi, 2019a; 2019b) (11)(13).

Pratiwi Rani (2016) Initial knowledge of mathematics is important, in addition to the required information and knowledge of students' prerequisites about the material

presented, so that teachers can plan their lessons better. According to Ega Gradini (2016) (14) Learning that ignores students' prior knowledge causes students' misconceptions to be more complex and stable. Epistemological barriers are often seen in the form of mistakes made by students in answering or responding to questions given (12,15). These mistakes can be impacted by the prior knowledge that students possess. (12).

The Two-Variable Linear Equations System (SPLDV) is a group of linear equations of two variables that are similar or connected to one another. This material includes the notion of terms, coefficients, constants, and variables related to the system of equations. (16). This system of two-variable linear equations is often used to solve problems around us. In the process of learning mathematics at school, students often make mistakes. Therefore, clear information is needed regarding students' obstacles in learning, especially epistemological barriers, especially in answering the Linear Equations of Two Variables, in order to improve their mathematical abilities. Small, (2017) (17) SPLDV learning which is discussed in this topic around big ideas or essential understanding, is described as follows, Equation is a statement of balance, that is, both sides are meant to represent the same value, Variables, can be used to describe relationships or things that are not efficiently known The identical algebraic expression or equation can be associated with diverse real-world scenarios, and conversely, operations retain their equivalent significance when applied to variables as they do when applied to numbers..

Some common mistakes students make when studying SPLDV material include errors in creating and interpreting models (18), difficulty understanding the relationship between linear equations and linear functions through graphical representations (19), as well as errors in carrying out problem solving procedures (20). This type of error is closely related to students' understanding of SPLDV concepts which must be mastered epistemologically.

Previous research regarding epistemological barriers included, (21). This study indicated that there were three types of epistemological barriers faced by students in overcoming SPLDV problems. The three types of barriers include conceptual barriers, procedural barriers, and technical operational barriers. These findings indicate that the pattern of epistemological barriers identified in this study is similar to the results of previous studies, even though the material studied is different. (22) students have epistemological obstacles. (23)Students have difficulty simplifying questions to their simplest form and often make mistakes when calculating the value of an arithmetic operation. (24) on epistemological barriers, there are students who experience procedural barriers.

The aim of research on epistemological obstacle in two-variable systems of linear equations is to recognize and comprehend the challenges students encounter when comprehending and resolving problems linked to systems of linear equations with two variables. This process enables students to discern the typical types of epistemological hurdles, including impediments in solving equations, challenges in algebraic calculation operations, difficulties in dealing with mathematical models, and obstacles in grasping the concept of variables. By understanding these obstacles, it is hoped that educators can develop more effective learning strategies and help students master the material better.

2. METHOD

The research employed a qualitative approach, specifically using the phenomenological method. From an epistemological standpoint, the phenomenological approach is grounded in the paradigm of knowledge and personal subjectivity, giving significance to individual perspectives and interpretations. In simpler terms, phenomenology entails the examination of experiences from the viewpoint of an individual. The aim of the phenomenological approach is to explain, identify and describe certain phenomena from the point of view of the person in the situation (25–27). This approach aims to determine the epistemological obstacle that occur in students at school. To find out, the researcher analyzed the student's prerequisite errors in solving a system of two-variable linear equation problems and also deepened insight into learning experiences and knowledge relevant to the material.

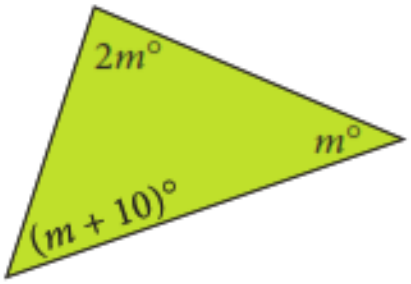
In this qualitative study, 12 students from grade eight students of Indonesian junior high school participated as research subjects. The purposive sampling method revealed learning obstacles regarding their conceptual understanding of systems of linear equations in two variables. Documentation in the form of a test serves to collect data. In addition, the interview technique was used to find out the students' constraints and to confirm the results of the test analysis in solving the prerequisite problem of a system of two-variable linear equations.

In this study, the validity of the material was determined using the triangulation method, namely comparing the results of the interviews with the tests given. Triangulation is a technique used to check the validity of data for validation or comparison of external data (28). This study uses data analysis, according to Miles and Hubberman (2002) (29) with three steps namely, data reduction, data presentation and drawing

conclusions. Data reduction in the form of interviews and tests was carried out with students. Then processed and presented back in a narrated text. Finally, conclusions are drawn to uncover epistemological barriers and refer to didactical designs (30) for students in solving two-variable linear equation system problems.

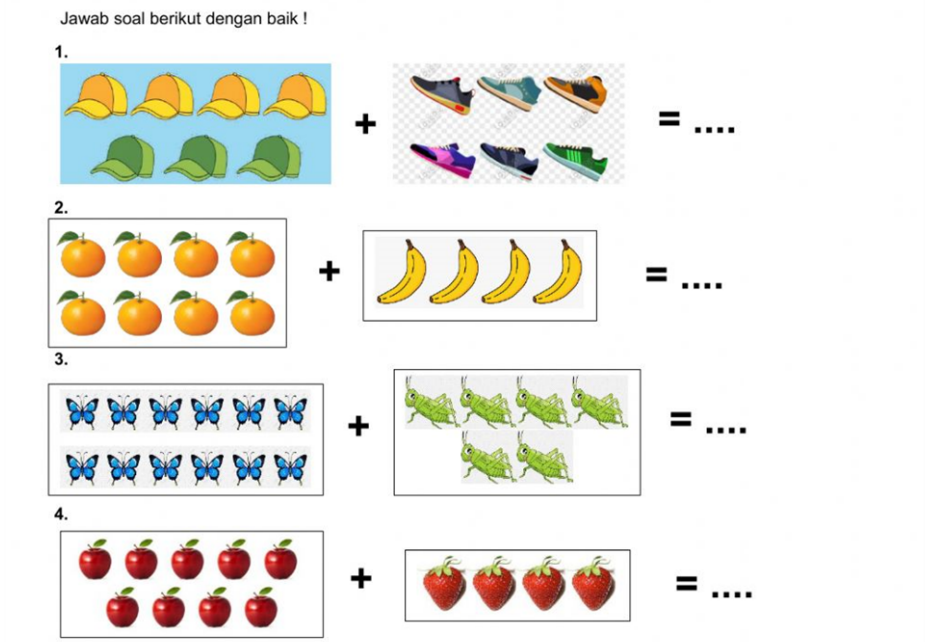
The questions given to students are as follows:

If a number is multiplied by two then subtracted by three to produce seven, what is that number?



If the total angles in a triangle are 180°, what is the value of m?

Count



Write down the mathematical model of, father's age two years ago equal to 2 times the age of his son.

3. RESULTS AND DISCUSSIONS

In this segment, we will elucidate the outcomes derived from the written responses of the participants and the findings from interviews conducted with five respondents concerning the topic of systems involving linear equations with two variables.

3.1. Understanding Equations

Equality is a balance statement that states that two expressions or values have the same value. An equation can contain one or more variables, and the main goal is to find the value of the variable that satisfies the equation. (17) Solve equations using relationships between numbers and between operations to determine equivalent and simpler forms of equations. Before understanding SPLDV, it is important for students to understand the basic concept of equations. Knowledge and understanding of equations is a strong foundation in understanding further mathematical concepts, including SPLDV which involves two variables and their relationship to one another. However, the equation here has not reached the two variables but only one variable because it wants to identify prerequisite material barriers for students. Like the results of students when answering question no 1. With the question A number if multiplied by two then subtracted by three produces seven, what number is that?.

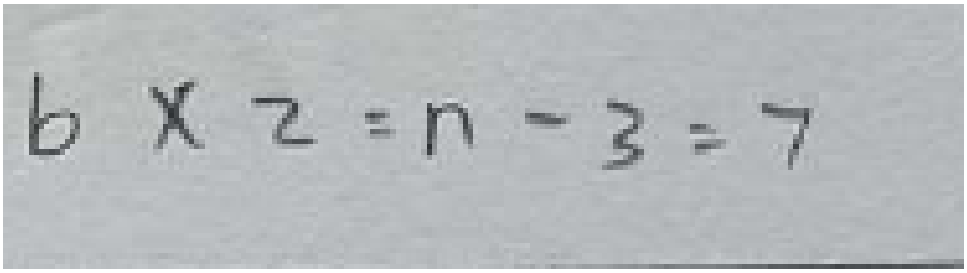


Figure 1: Equation Barriers to subject 1 (S1).

From the picture we can see students adding another variable, namely n, so students create a new equation, namely b x 2 = n – 3, but the researcher clarifies this answer by interviewing

R : What are you looking for in the question?

S1 : find a number sir

R : do you know if the answer has a new variable?

S1 : no sir, I am confused

R : how can you make variable n appear

S1 : I intend to produce a temporary value sir

R : how do you continue your answer

S1 : I can't anymore sir

Based on the interviews with these students, it was observed that they faced challenges in solving the given questions. However, there was recognition for their efforts to generate interim values. The aspiration is that in the future, students will gain a better understanding that the equation's left side should be equivalent to the right side. It's different from Subject 2 where they can answer correctly but don't write the equation correctly.

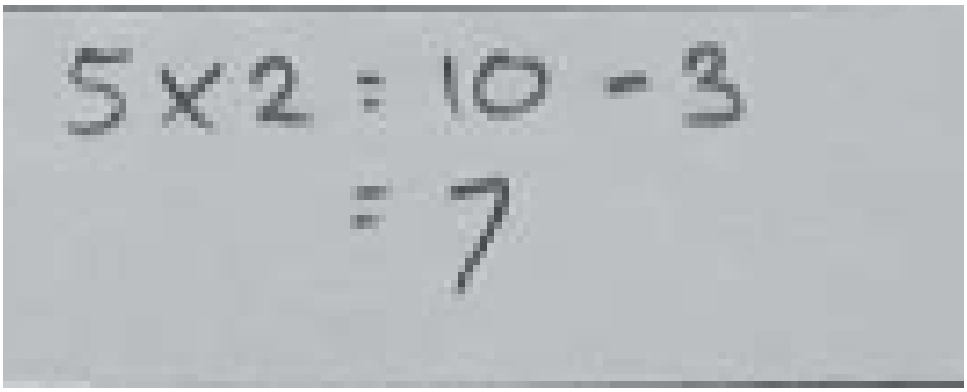


Figure 2: Equation Barriers to subject 2(S2).

R : How many answers to the question?

S2 : 5 sir

R : yes true, but is the method like that

S2 : I don't know sir, I just guessed

R : Is 5 x 2 = 10 -3 ?

S2 : No sir, I mean 10 is the result of 5 x2

R : Next time in writing the equation, it shouldn't be like that

S2 : ok sir, thank you

From subject 2 we get the conclusion that subject 1 wants to write like subject 2, but has not been able to do it. Besides that, writing equations is still a habit for students, as happened in subjects 1 and 2.

3.2. Algebraic arithmetic operations

Perbowo and Anjarwati (2017) (20) state that having a good understanding of algebraic operations techniques is very important because mathematics involves many numerical calculations and the application of algebraic operations. This understanding is important because algebraic operations form the foundation for almost all branches of mathematics, from the simple to the complex. By mastering algebraic operation techniques, students can more easily understand and solve various types of mathematical problems, both at the basic and advanced levels**.** Before studying the matter of a system of two-variable linear equations, it is important for us to learn algebraic arithmetic operations as a prerequisite material, although there are still students who are still confused, like the answers in subject 3 below.

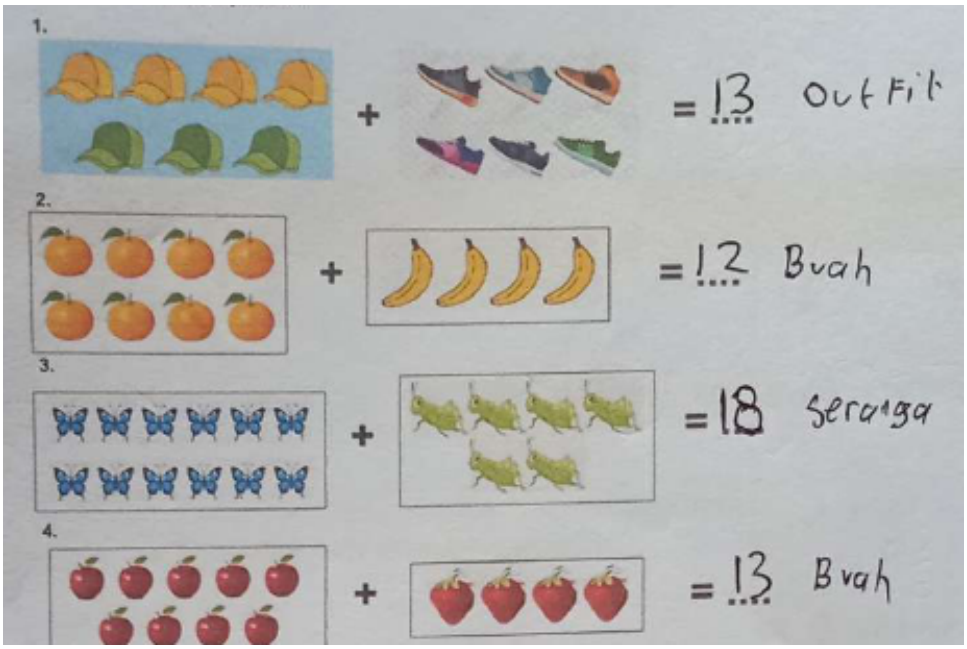


Figure 3: Barriers to algebraic arithmetic operations subject 3(S3).

From the picture it can be seen that students cannot add up algebraic operations, but form a new variable.

R : are you sure 8 oranges plus 4 bananas is 12 pieces

S3 : sure sir, 8 plus 4 equals 12

R : 12 of them, 12 oranges or 12 bananas

S3 : 12 pieces sir

R : why is there fruit in the answer

S3 : because oranges and bananas are the same fruit

R : whether two different variables can be added

S3 : No sir

R : Why do the answers add up?

S3 : because I think the fruit is the same, sir

Subject 3's conclusion is that there is still confusion concerning the combination of contextual variables. For instance, when asked about the scenario where x represents the number of oranges and y represents the number of bananas, the student responds with 12 xy. However, it should be noted that xy is a newly introduced variable within the given problem. This question should not have been possible because the two different variables could not be added together, but all the students studied answered the question by adding a new variable. From these answers, in fact the students also could not understand the variable

3.3. Understanding Variables

Concluding that students have not fully understood the meaning of variables, even though the answers provided are correct, indicates that students perceive variables merely as terms or abbreviations without truly understanding their deeper meaning. In mathematics, variables represent specific quantities or values, not just symbols without meaning. This mistake should not be overlooked, as it can hinder further understanding of more complex mathematical concepts. According to Sommerhoff and Ufer (2019) (31), the use of symbols plays a crucial role in the learning process of mathematics. Initial understanding of mathematical concepts largely depends on how well students grasp the symbols used within those concepts. These symbols are not merely signs or notations but represent specific values or relationships that must be understood properly for mathematical concepts to be accurately comprehended. If students lack a deep understanding of symbols like variables, it can lead to confusion when applying mathematical concepts later on. Therefore, it is important to ensure that students not only provide correct answers but also understand the fundamental concepts behind the symbols they are using

Concludes that students do not fully understand the meaning of the variable, even though the answers presented are correct, so that the variable fulfills a certain quantity/value, not just a term or abbreviation. These errors should not be tolerated because Sommerhoff and Ufer (2019) (31) revealed that in the process of learning mathematics,

the use of symbols has a very important meaning because the initial understanding of mathematical concepts is how to understand the symbols in these mathematical concepts.

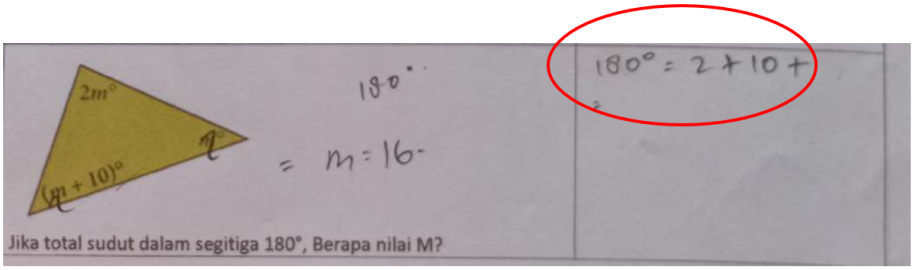


Figure 4: Hambatan Variabel Subyek 4 (S4).

From Figure 4, it can be seen that students cannot continue answering these questions because there are variables. So the researchers conducted interviews with subject 4 as follows.

R : why not continue the answer?

S4 : because I'm confused, there's m sir.

R : Don't you know what m is in that question?

S4 : I don't know sir, how about it?

R : m is a variable in the question, m is the angle value

S4 : oh ok sir, got it

R : I ask again, why did the m in 2m disappear?

S4 : because previously I didn't know the variable, so I omitted it.

The results of the interviews concluded that students still did not understand what a variable was, so those that contained variables were simply omitted. From these answers, students are almost inclined not to be able to do algebraic operations, but the basis of algebraic operations themselves must know what a variable is. Therefore, the researcher tried to ask subject 4 whether he knew the variable or not.

3.4. Mathematical Models

There are several findings related to obstacles in understanding the system of two-variable linear equations (SPLDV), which align with previous studies. Rismawati et al. (2016) (32) stated that one of the conceptual barriers was students' lack of understanding of the requirements for preparing the SPLDV. Students have difficulty modelling

the SPLDV problem properly according to predetermined conditions. Another study conducted by Modestou and Gagatsis (2007) (19) also found similar results, where errors in mathematical modelling occurred due to students' lack of understanding of the problems to be solved. This shows that a lack of understanding of the problem itself can lead to difficulties in preparing the SPLDV. In addition, related to these obstacles, the research by Rasnawati et al. (2019) (33) also emphasizes the importance of understanding the basic algebra concepts as a prerequisite for understanding the SPLDV concept. Without a sufficient understanding of the basic concepts of algebra, students will face difficulties in solving SPLDV. As the results of the answers of students who were still confused about making a mathematical model, they were given the following questions: Write a mathematical model for, the father's age two years ago was equal to 2 times the age of his son!

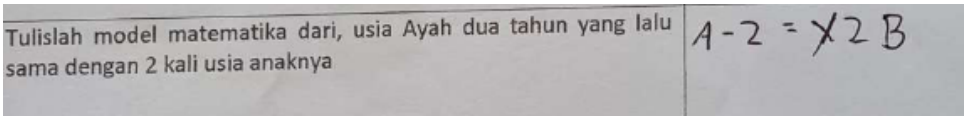


Figure 5: Barriers to the subject's mathematical model 5 (S5).

These inquiries reveal that students tend to struggle with articulating mathematical models. Despite the clarity of the questions designed to elicit mathematical models, students make attempts to formulate them but often make errors in the process. The results of the interview are as follows:

R : are you sure about the answer?

S5 : actually not sir

R : which part is confused?

S5 : confused to understand the question

R : is writing, father's age two years ago is A-2?

S5 : Sir, that's right.

R : good, why is it that after equal to there is multiplication?

S5 : The important thing is that I write according to your understanding, sir

R : multiplication should not be placed after the equal

S5 : Alright sir

R : what did A mean in writing the symbol

S5 : A means father, sir

R : If I give questions A + A equal to how many

S5 : 2A sir

R : can daddy be added?

A should be father's age not only father's.

S5 : Alright sir

In understanding the problem, sometimes students experience difficulties so that they experience obstacles in writing the model. According to Santoso, (2019) (16) there were three mistakes in working on SPLDV questions, one of which was a misunderstanding of the problem. In writing the model the researcher also wants to know other obstacles, one of which is understanding variables, students are still confused about modeling variables and giving examples. When for example it is incomplete, it will be the wrong meaning.

4. CONCLUSION

Although not yet up to the elimination test, substitution, and graphics. Prerequisite material or initial material needs to be identified more deeply, because if the prerequisite material cannot be mastered it is assumed that further understanding of the material cannot be mastered either, this is understood as an epistemological obstacle. After analyzing the results, which include test outcomes and student interviews as described earlier, the researcher reached the conclusion that the obstacles faced by students in comprehending the material on systems of linear equations with two variables can be outlined as follows, (1) Obstacles in understanding equations, students were confused in interpreting equations between the left and right sides to be balanced, students wrote symbols that did not match the equations that apply in mathematics, but wrote according to their own understanding. (2) Obstacles to algebraic arithmetic operations, students experience difficulties if there are variables in the operation, because they are confused about understanding the variables that are in the coefficients, so students try to eliminate these variables. (3) Obstacles to understanding variables, here students still cannot interpret variables properly, so students misinterpret these variables. (4) Obstacles to Making Mathematical Models, Students encounter challenges in comprehending the questions, leading to difficulties in accurately expressing mathematical symbols.

Overall, these findings reflect that problems understanding the requirements for compiling SPLDV and basic algebraic concepts can become an obstacle for students in understanding the prerequisite material for completing SPLDV effectively. Therefore, it is

important for educators to pay special attention to understanding the basic concepts and requirements in studying SPLDV in order to help students overcome these obstacles.

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