HIGH SCHOOL STUDENTS' ALGEBRAIC THINKING ABILITY ON ETHNOMATHEMATICS-BASED THREE-VARIABLE LINEAR EQUATION SYSTEM PROBLEMS

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Abstract

Algebraic thinking ability is a fairly important ability that must be possessed by students, but in working on test questions there are still some mistakes made by students. Therefore, this study aims to find out what the most mistakes made by students in solving the algebraic thinking ability test refer to Newman's Error Analysis theory and also to find out what factors influence student errors in solving the algebraic thinking test. The research was conducted at public high schools in Cianjur in the even semester of the 2021/2022 academic year. Using a quantitative approach with the type of research conducted is descriptive. The algebraic thinking ability test instrument given as many as 3 questions to 29 students as research subjects within 60 minutes in addition to the test, interviews were also conducted to find out what factors influenced students in making mistakes. The results showed that the most mistakes made by students in working on algebraic thinking ability test questions were in the encoding indicator of 34%, the factors that influenced student errors included students not being used to working on problems systematically, students were also not used to writing answers completely, students did not understand the concept of algebra and did not understand the problem.

Keywords: Algebraic Thinking Ability, Newman's Error Analysis, Three Variable Linear Equation System.

INTRODUCTION

The process of learning mathematics at the primary and secondary education levels faces a rather difficult challenge in preparing a generation of nations that excel and have mathematical abilities. By studying mathematics students are expected to be able to hone their ability to think logically, analytically, systematically, critically, innovatively and creatively. Therefore, by studying mathematics students are not focused on counting activities but are also able to reason, think critically and logically, can solve mathematical problems. Algebra is a branch of mathematics that studies symbols that can represent an unknown number. Algebra has a relationship with other branches of science such as statistics, calculus etc. where thinking algebraically can help simplify a problem in everyday life. Students' understanding of the operation of algebraic forms is still low.

According to Sadikin and Rezky Agung Herutomo, students' abilities are still low in each dimension of algebraic reasoning ability (Sadikin and Herutomo, 2019). Students' understanding of the operation of algebraic forms is still low and not in accordance with the Graduate Competency Standards (Dwirahayu, Kustiawati and Yanti, 2018) . Indonesian Law No. 20 of 2003 concerning the National Education System article 37 emphasizes that mathematics is one of the compulsory subjects for students at the primary

and secondary education levels. The study materials of mathematics, including arithmetic, measurement, and algebra are intended to develop the logic and thinking skills of students (Indonesia, 2006)

Algebraic thinking includes recognizing and analyzing patterns, studying and representing relationships, making generalizations and analyzing how things change." (Seeley, 2004). Algebraic thinking describes student activities in learning algebra (Permatasari, 2021). Algebraic thinking is a way of thinking that involves the development of ways of thinking using algebraic symbols (Kieran, 2004). Success in algebra depends on at least 6 types of mathematical thinking skills as follows: Generalization, Abstraction, Analytical Thinking, Dynamic Thinking, Modeling, and Organizing (Lew, 2004).

Algebraic thinking ability is a fairly important ability that must be possessed by students. To minimize student errors in algebraic thinking can be done by analyzing student errors. To find out the types of errors and the causes of errors made, it is necessary to analyze more deeply on each error made by students. The analysis that will be used in this study is Newman's Error Analysis The reason for using Newman's Error Analysis in this study is so that it can reveal what mistakes are made by students in solving algebraic thinking ability test questions comprehensively in terms of language and mathematical processing. Newman's Error Analysis Theory. Newman's Error Analysis is a theory for analyzing errors made by students in solving mathematical problems, according to Newman, errors in working on mathematical problems can be divided into five types of errors, namely Reading error (reading error), Comprehension error (understanding error), Transformation error (error in transformation), Process skills error (error in process skills), Encoding error (error in notation) (Yusnia and Fitriyani, 2017).

There are several studies using Newman's Error Analysis on the material of the three-variable linear equation system, for example (Dewi and Kartini, 2021). looking at errors and factors that cause errors, as for (Putri and Nur, 2022) analyzing according to the 5 stages in Newman's Error Analysis theory but not specifically on algebraic thinking ability. Therefore, researchers are interested in analyzing student errors in algebraic thinking. There are several studies (Candraningsih and Warmi, 2023) analyzing the characteristics of story problems. (Pramasdyahsari, Amillia and Sugiyanti, 2023) on PISA questions. In this study, the characteristics of the questions on the ethnomatmatics approach. So based on the description above, the focus of this study aims to determine students' algebraic thinking errors in the ethnomathematics context in terms of Newman's Error Analysis theory and including what factors affect the most mistakes made by students.

METHOD

The research method used is the survey method. Using a quantitative approach and the type of research conducted is descriptive research. This research was conducted at one of the public high schools in Cianjur. Taking research subjects in this study is by using the Purposive Sampling Sampling technique, which is a data collection technique with certain considerations (Zuchri, 2021). Consideration of subjects in this study is seen from subjects who have higher science abilities, based on the results of discussions with the subject

teacher, the subject used for this study is class X. Furthermore, researchers will group scores from high, medium to low based on the test results given. Grouping of high, medium, and low groups is determined from the average value and standard deviation of the algebraic thinking ability description test scores. The criteria for grouping research scores can be seen in Table 1.

Table 1. Criteria for Grouping Research Values

Criteria	Value Interval
High	$\overline{x} + \sigma < x \leq 100$
Medium	$\overline{x} - \sigma < x \leq \overline{x} + \sigma$
Low	$x \leq \overline{x} - \sigma$

Description:
x = student score
$\overline{x}$ = average student score
σ = standard deviation

The data in the study were obtained from the algebraic thinking ability test, the test was in the form of descriptions and interviews which were then analyzed descriptively. to determine the differentiating power and liking index of each item. Researchers use tools in the form of software anates ver. 4.0.5, software developed by Drs. Karna To, S.Pd. and Yudi Wibisono, S.T. The lattice of algebraic thinking ability test instruments is described in Table 2.

Indicators of Algebraic Thinking	Question Number
Generalization (The process of finding a pattern or a shape)	1
Abstraction (The process of extracting mathematical objects and relationships based on generalizations)	1
Analytical Thinking (The process of finding unknown values with the aim of finding the next step)	2
Dynamic Thinking (The process of thinking by involving variables with objects that can change)	3
Modeling (The process of representing complex situations using mathematical symbols, to investigate situations with models, and to draw some conclusions)	2
Organization (presents combinatorial thinking to find all independent variables, which is very important in problem-solving activities, to make it easier to control)	3

The data analysis technique in this research is descriptive qualitative, aims to describe the algebraic thinking ability of the research subject in detail and in depth, the data analysis of this research is a little long and wide but with an easy-to-understand analysis flow.

RESULTS AND DISCUSSION

The algebraic thinking ability test was done by 29 students, to find out the percentage of the highest and lowest scores obtained by students presented in the statistical table of algebraic thinking ability presented in Table 3.

Table 3. Algebraic Thinking Ability Statistics Data

No	Statistics	Results
1	Max Value	97,8
2	Min Value	31,1
3	Mean	58,4
4	Standard Deviation	19,9
5	Skore >KKM	12
6	Skore <KKM	17

Table 3 shows the average of students' algebraic thinking ability of 58.4. In accordance with Table 3, the algebraic thinking ability of students is in the medium criteria. Then also obtained a standard deviation value of 19.9 where the value is used to determine the criteria for high, medium and low in students' algebraic thinking ability, can be seen using Table 4.

Table 4 Student Algebraic Thinking Ability Criteria Data

Criteria	Sum	Mean	(%)
High	5	86,44	17
Medium	16	61,74	55
Low	8	34,03	28
Total	**29**	**182,21**	**100**

In table 3, we can see that the percentage of high criteria is 17% with an average of 86.44 and the number of students on high criteria is 5 people. Then the highest percentage is in the medium criteria, which is 55% with an average score of 61.74 students with medium criteria as many as 16 people. While the percentage of low criteria was 28% with an average score of 34.03 and students with low criteria were 8 people. From these data, it shows that most students' algebraic thinking skills are in the medium to low criteria. Then the results of the algebraic thinking ability indicators are presented in Table 5.

Tabel 5. Algebraic Thinking Ability Indicator Result

Indicator	Skor	%
Generalization	3	2

	40	2%
Abstraction	237	16%
Analytical Thinking	320	21%
Dynamic Thinking	180	12%
Modelling	343	23%
Organization	103	7%

In table 5, information is obtained about the score of each indicator of students' algebraic thinking ability, the data shows that the highest percentage of students' algebraic thinking ability is 23%, namely the modeling indicator. And the indicator that gets the lowest score is the organization indicator by 7%. This shows that many students master the modeling indicator and can model a mathematical problem into an algebraic form, but many of the students have not found a piece of important information for solving a problem which then the information is arranged in algebraic form so that the value of the organization indicator is low. The results of the analysis of students' algebraic thinking ability errors are in Table 6.

Tabel *6*. Students' Algebra Thinking Ability Error Analysis Score

NO	Algebra Thinking Ability	Error Analysis					Jumlah
		Reading (%)	***Comprehension (%)***	***Transformation (%)***	***Process Skill (%)***	***Encoding (%)***	
1	***Generalization***	0%	3,8%	1,0%	2,1%	4,0%	**11%**
2	***Abstraction***	1,8%	4,4%	3,0%	6,7%	6,9%	**23%**
3	***Analytical Thinking***	0,7%	3,4%	2,4%	2,6%	4,0%	**13%**
4	***Dynamic Thinking***	3,3%	4,7%	6,6%	7,1%	7,6%	**29%**
5	***Modelling***	0,8%	2,2%	2,4%	2,3%	2,9%	**11%**
6	***Organization***	6,2%	7,4%	7,9%	8,2%	8,5%	**38%**
	Sum	**13%**	**26%**	**23%**	**29%**	**34%**	

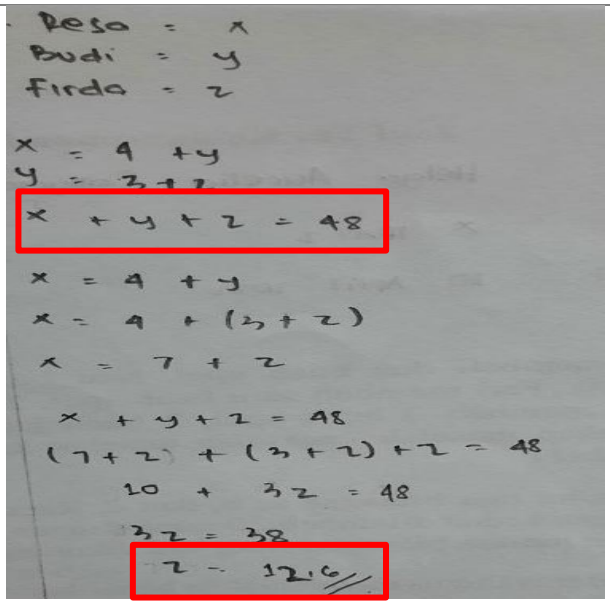
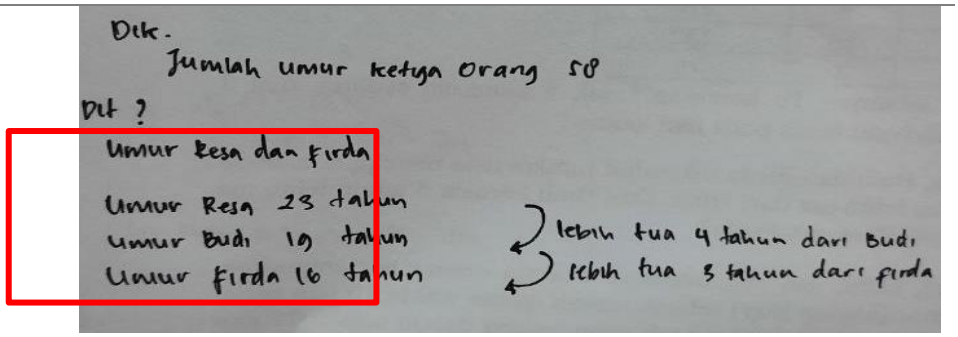
Table 6 shows 6 indicators of algebraic thinking skills analyzed based on Newman's Error Analysis indicators. From the table above, it can be seen that the error that has the largest percentage is the organization indicator, which is 38%, this can be influenced by the dynamic thinking indicator with the second largest error percentage of 29%, many students have not been able to carry out the process of manipulating information to obtain unknown values, this results in the process of compiling information, students cannot compile information algebraically due to lack of data or information obtained causing a high

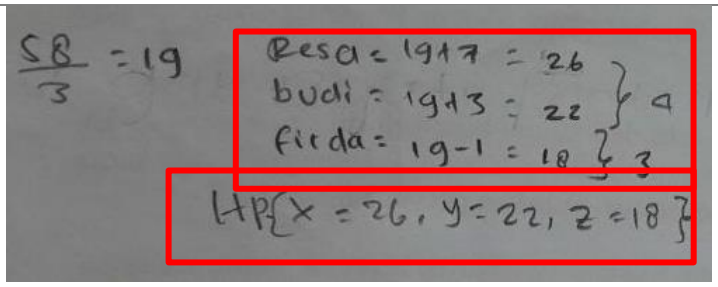
percentage of errors in the organization indicator. Then the indicator of algebraic thinking ability with a fairly low percentage is the generalization and modeling indicator, which is 11%, this shows that students are able to identify objects, create linear equations of three variables, and also model a problem.

The analysis of the results of the assessment of algebraic thinking skills with Newman's error analysis will be described with the following description:

1) Error on question number 1

Test instrument number 1 includes two indicators, namely, generalization and abstraction. In problem number 1, it is known that 3 people bought 3 types of fruit with different weights, students are asked to state the problem in SPLTV form. The result of errors in generalization ability is 11%. Student answers with errors are presented in Figure 1.

High Criteria

(i) Answer to question number 1 LA117
Medium Criteria

(ii) Answer to question number 1 LA101
Low Criteria



(iii) Answer to question number 1 LA104

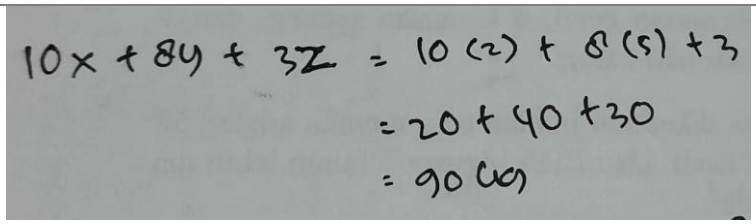
Figure 1. Students' Answers with Errors in Problem Number 1

Figure 1 shows that students from all three criteria both high, medium, and low have good generalization skills as evidence that all three criteria are able to present the form of equations from the problems listed in the problem, but students with medium criteria make mistakes in comprehension, namely students give answers that are not requested by the problem. In abstraction ability, some students skipped this abstraction part, students with high and low criteria made mistakes in transformation and process skills, and only students with medium criteria defined the problem in the algebraic form first and then made an equation.

2) Errors in question number 2

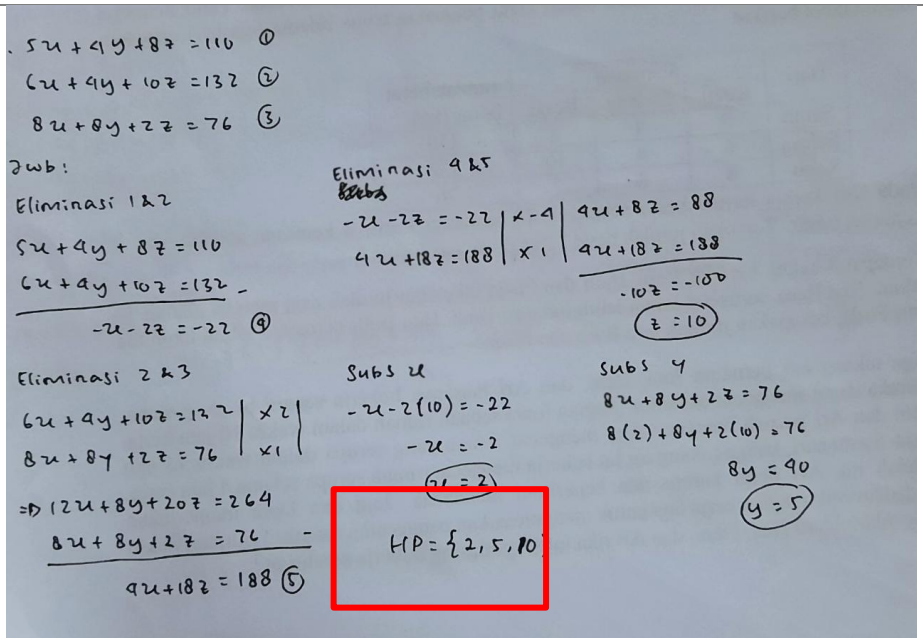
Test instrument number 2 includes Analytical Thinking and Modeling indicators, in question number 2 it is known that the good shop provides rice in three small, medium, and large packages. Then a data table is presented for 3 days of sales of the three packages and the amount of heavy rice sold (kg) students are asked to find the amount of weight on the 4th day with the known amount of rice sold per package on that day. Students' answers with errors are presented in Figure 2.

High Criteria



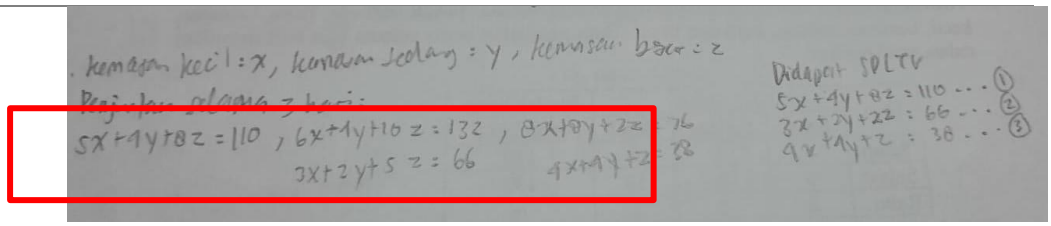
(i) Answer to question number 2 LA109

Medium Criteria



(ii) Answer to question number 2 LA129

Low Criteria



(iii) Answer to question number LA104

Figure 2. Student Answers with Errors in Problem number 2

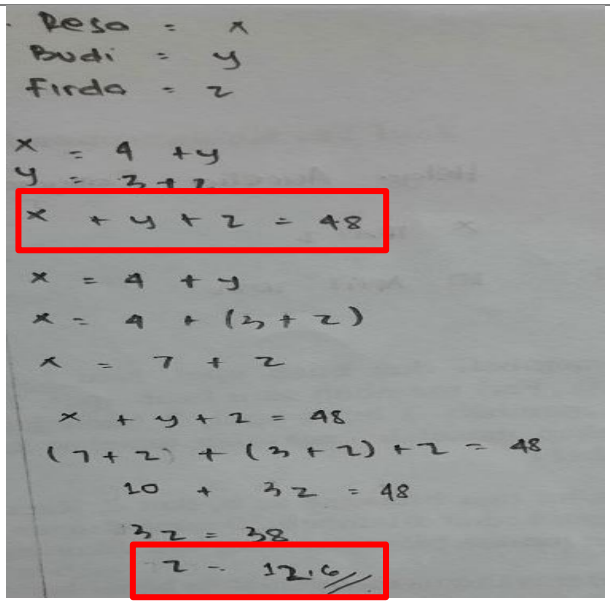
In Figure 2, students with high criteria answered the question correctly, the mistakes made by students were that students skipped the comprehension, transformation, and process skills stages and immediately wrote down the answers so that it could not be identified where students got these values.

While students with medium criteria do the encoding stage, namely entering the information that has been obtained into the problem at the beginning, students only mention the values that have been obtained and do not fulfill the encoding stage. Furthermore, students with low criteria make mistakes in transformation, process skills, and encoding, students change the information they get from the table into an algebraic form where it is not the answer requested by the problem.

3) Errors in question number 3

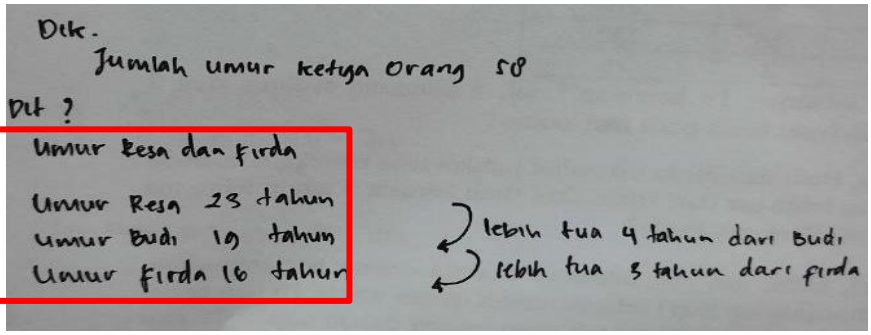
Test instrument number 3 includes indicators of dynamic thinking and organization, in this question, it is known that there are 3 siblings, the ages of the three are known, and the age comparison. Students are asked to find the sum of the ages of 2 of the 3 siblings. Students' answers with errors are presented in Figure 3.

High Criteria



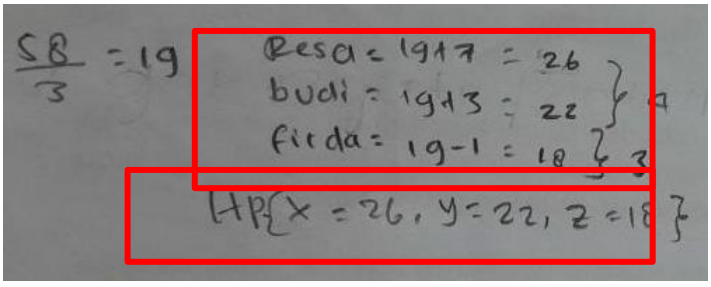
(i) Answer to question number 3 LA122

Medium Criteria



(ii) Answer to question number 3 LA125

Low Criteria



(iii) Answer to question number 3 LA118

Figure 3. Student Answers with Errors in Problem number 3

From Figure 3 we can see that students with high criteria students are able to reach the transformation stage, it's just that students make mistakes in writing information that

should the total age of the 3 siblings is 58 students instead write 48 so that there is a mistake for the next steps While students with medium criteria make mistakes in the transformation process, process skills, and encoding, in the picture students do not change the information they get from the problem into algebraic form causing, students are also wrong in processing information from the problem so that students do not get more unknown information causing students to write wrong answers and conclude answers. Low students do not do the transformation stage, then the steps students take to work on the problem are not appropriate, instead of answering what is asked by the question, namely the number ages of 2 of the 3 children whose information is already known, students answer with the solution set which means that students do not reach the comprehension stage.

After analyzing the data, it is known that there are still many students who still make mistakes, errors in the indicators of students' algebraic thinking ability which are found in the order of many errors the ability of Organization, Dynamic thinking, Abstraction, Analytical thinking, Modeling and the lowest is Generalization. In accordance with Newman's Error Analysis, the most mistakes made by students when sorted are at the encoding, process skill, comprehension, transformation, and the smallest reading stages. So that the most mistakes are in writing and summarizing answers, this is also influenced by the comprehension stage of students who also have a fairly high percentage of errors due to students' lack of understanding of the problem. In line with research conducted by Son, (Son, Darhim and Fatimah, 2019) which states that students make mistakes from comprehension to encoding. In contrast to research conducted by (Yusnia and Fitriyani, 2017)where in their research it was found that the most mistakes made by students were transformation errors.

After conducting interviews, it was found that the factors that influenced students' errors on the algebraic thinking ability test were that some students were not used to working on problems systematically, some students were also not used to writing answers completely, students said that the answers they got based on this logic showed that students did not understand the concept of algebra itself, students were also unable to get information from the problem due to students' lack of understanding of the problem, this is in line with research conducted by (Farida and Hakim, 2021) where in their research they stated that students lacked an understanding of the concept of algebra.

Therefore, it is better for teachers to familiarize students to answer test questions completely and systematically and focus more on the concept of understanding algebra. To analyze student errors, especially in algebra material, teachers can use Newman's error analysis theory to find out where the errors made by students are and further teachers can apply appropriate learning methods.

CLOSING

Conclusion

Based on the research that has been carried out on high school students in Cianjur on the material of the system of linear equations of three variables, it can be concluded as

follows, 1) The most mistakes made by students in solving the algebraic thinking ability test referring to Newman's Error Analysis theory if sorted from the largest percentage is encoding. 2) The influencing factors are students do not understand the concept of algebra, students are not accustomed to writing answers in detail, completely, and systematically (starting from known, asked, completed, and arriving at the conclusion), also students are unable to get information from the problem because of students' lack of understanding of the problem, and students lack understanding of the concept of algebra.

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