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Analysis of Elementary School Students' Computational Thinking in Learning with Artificial Intelligence-Assisted Mathematical Activities

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Abstract

This study aims to analyze elementary school students' computational thinking abilities in mathematics activities assisted by artificial intelligence. This research is motivated by the low level of students' numeracy literacy and the limited use of AI in mathematics learning that requires analytical skills from students. This interpretive qualitative research was conducted on sixth-grade students at an elementary school in Bantul, focusing on the surface area of composite geometric shapes. Data were collected through observations, tests, and interviews to describe students' thinking processes. Data validity was tested using triangulation. The results showed

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differences in students' computational thinking (CT) abilities in the high, medium, and low categories in meeting the indicators of decomposition, abstraction, algorithms, debugging, and generalization. AI-assisted mathematics activities helped students understand concepts and develop CT, especially in identifying and correcting AI errors. Therefore, AI needs to be used as a learning support medium to optimize students' CT abilities. These errors encourage the development of computational thinking abilities in students so that students are able to think critically to correct errors made by AI. Overall, this study confirms that AI-assisted mathematics activities are a strategic tool in developing elementary school students' computational thinking skills, as long as AI is positioned as a learning support medium and not as a substitute for students' thinking processes.

Keywords

Mathematics Activities, Artificial intelligence, Computational thinking, Elementary school.

I. Introduction

1.1 Introduce the Problem

The era of globalization 5.0 is marked by the rapid development of information and communication technology, which has penetrated various aspects of life, including education. In the 21st century, individuals must possess 12 skills, one of which is learning and innovation skills. Learning and innovation skills include (1) critical thinking, (2) creativity, (3) communication, and (4) collaboration. For students, critical thinking skills are essential to encourage them to solve problems.

Critical thinking is necessary in problem solving because critical thinking will provide the right direction in thinking and working, and help in finding the relationship between one factor and another precisely.(Dharma et al., 2022)Critical thinking is also needed in solving mathematical problems. Mathematical problem solving is a more complex thought process. Students will think more critically in investigating problems and be better at responding to and solving them.(Layali & Masri, 2020). Mathematical problem solving also involves solving problems using logic, systematic reasoning and finding solutions.

Mathematical problem-solving skills can be enhanced through computational thinking, which serves as a conceptual foundation to strengthen these abilities. Computational thinking is one of the most important skills to be honed from an early age because in the information age, Industry 4.0, or Society 5.0, humans live in both the real world and the digital world.(Rahmawati et al., 2024). Definition of computational thinking according toWing (2010),Computational thinking can be understood as the thought process involved in formulating problems and their solutions so that the solutions are represented in a form that can be effectively implemented by information processing agents. The main indicators of computational thinking according toAngeli & Valanides (2020), as follows: Decomposition, Abstraction, Algorithm, Debugging, and Generalization.

Computational thinkingoften associated with mathematical activity. Mathematical activity can be defined as a process that connects everyday experiences with abstract concepts in mathematics. Mathematical activity is something we do at any given time that is rich, diverse, and complex. Mathematical activity is not limited to the application of algorithms and proof of theories.(Giaquinto, 2005). Mathematical activities must involve various forms of cognitive action, not just the activity of calculating or applying formulas mechanically.

In the era of digitalization 5.0, technological developments are creating much-needed innovations. One of the most sought-after and widely used is artificial intelligence. AI is the ability of systems to perform tasks similar to human intelligence, such as problem-solving, planning, and learning.(Fauzi et al., 2024).

AI usage in Indonesia reached 1.4 million visits, with CHATGPT, one of the AI tools used by more than 60% of the total, as found in the research analysis. AI was accessed by more than 63% of mobile users.(Rasyid, 2024)Chat GPT, or Conversational Generative Pre-trained Transformer, is a widely used AI technology. The advantage of chat GPT lies in its ability to answer questions, complete various types of tasks, and communicate with users in a conversational manner.(Rachbini et al., 2023).

Based on the description above, it can be concluded that GPT chat is an AI technology. Its ability to provide information that solves tasks in a single platform makes GPT chat a highly efficient tool.However, in reality, chatGPT isn't always reliable. In solving problems, chatGPT encounters errors when presenting the solution steps.

Based on observations, chatGPT was able to answer all the questions given. However, when presented with a mathematical story problem on the geometry of a composite solid, specifically calculating the surface area, chatGPT was unable to solve it completely. In its calculations, chatGPT would only subtract one side of the solid while still calculating the full side of the solid without subtracting. This error is often overlooked, leading students to misunderstand the concept.

Previous literature reviews have shown that extensive research has been conducted on CT. One study demonstrated variations in students' CT abilities across indicators in solving contextual mathematical problems.(Faradillah et al., 2025). In addition, there is a study that found that the majority of students are in the moderate category and still experience difficulties in systematically compiling algorithms for number pattern material.(Kamil et al., 2021). A previous study also showed that students with high abilities were able to integrate all CT indicators, while those with low abilities still had difficulty in the abstraction and algorithm stages.(Junaedi et al., 2024).

Based on previous literacy studies byFaradillah et al (2025);Kamil et al (2021);Junaedi et al (2024),There has been no research that specifically discusses the analysis of elementary school students' computational thinking in mathematical activities using the help of artificial intelligence, especially the material on the area of combined cube-shaped solids for sixth-grade elementary school students, so this research can help the latest findings that discuss elementary school students' computational thinking andpresenting innovation through AI integration in elementary school students' mathematics activities. The urgency of this research is based on the fact that amidst the massive use of AI in Indonesia, students need to be equipped with the ability to not just accept the output of technology raw. This research focuses on the analysis of elementary school students' computational thinking in mathematical activities with the help of artificial intelligence, especially the material of the combined area of cubic cuboids in grade VI (six) elementary school students. Based on this background, the purpose of this study is to describe the analysis of elementary school students' computational thinking abilities in mathematical activities using artificial intelligence assistance on the material of the combined area of cubic cuboids.

II. Method

This research uses a qualitative method with an interpretive paradigm. The method applied is a naturalistic method that emphasizes the naturalness of data sources in the field.(Tabrani, 2023). Researchers selected informants according to their needs. The sampling technique in this study was purposive sampling based on the consideration that not all individuals in the population meet the required criteria in the study. Therefore, sample selection was carried out based on predetermined criteria, namely students who represent the categories of high, medium, and low computational thinking abilities so that they can provide in-depth data related to the phenomenon being studied.

This research was conducted at a public elementary school in Bantul, Yogyakarta, with sixth-grade students as the primary informants. Additionally, sixth-grade teachers and the principal served as supporting informants.

The research data consists of primary and secondary data, data obtained from observations, interviews, documents, reports, and documentation that can support the research. Data collection was carried out through three techniques: 1) Observation, 2) Interviews, 3) Tests, and 4) Documentation. Data analysis uses the Miles and Huberman model, namely: 1) Data reduction, 2) Data presentation, and 3) Conclusion drawing. To ensure the credibility of the findings, this study uses triangulation techniques, namely: 1) Method triangulation, namely testing data to ensure its reliability by finding out and verifying data from the same source but using different techniques.(Nurfajriani et al., 2024)2) Source triangulation, namely data obtained can be trusted because the data goes through a checking process during research on several sources or informants and produces a conclusion that has been analyzed.(Nurfajriani et al., 2024).

III. Result and Discussion

Research result

Various innovations have been created to support more engaging and meaningful learning for students, and one innovation widely used today is the use of artificial intelligence in education. The use of AI in mathematics lessons can increase student motivation through various aspects, creating a more effective learning experience.(Syaukani et al., 2025). AI will also open up opportunities for students to develop high-level thinking skills, namely computational thinking. Computational thinking in students can be honed through the integration of AI in learning

Students are given the opportunity to hone their computational thinking skills by independently solving problems, then using AI to support their learning. Computational thinking levels are determined through an in-depth analysis of post-test documents given to students following AI-assisted mathematics instruction. The data obtained can describe students' computational thinking abilities after the learning process.

This study used a purposive sampling technique. Six students were selected as the main subjects because they represented the high, medium, and low computational thinking categories based on the initial test results. From the entire sixth grade, six students were selected, consisting of two students in the high category, two students in the medium category, and two students in the low category, for further analysis through interviews and observations. The determination of students' computational thinking levels used the following formula:

Table1. Standard Deviation

Number of Students	Minimum score	Maximum score	*Mean*	*Standard Deviation*(SD)
6	20	80	64.17	21.19

Computational thinking is categorized into three levels: high, medium, and low. According to Azwar (2021), the categorization formula is as follows:

Table2. 3-Level Categorization

Category	Score
Tall	$(M + 1SD) <= \dot{X}$
Currently	$(M–1SD) <= \dot{X} < (M + 1SD)$
Low	$\dot{X} < (M–1SD)$

Table1. Categorization of Computational Thinking

Category	Score
Tall	*85.35 <= $\dot{X}$*
Currently	*42.97 <= $\dot{X}$ < 85.35*
Low	*$\dot{X}$ < 42.97*

The following is the computational level of elementary school students in artificial intelligence-assisted mathematics activities based on post-test documents that have gone through analytical procedures and computational thinking categorization:

Table4. Computational thinking level of students

Student Number	Student Name	Learning outcomes (Post-test)	CT Level
Student 1	THERE IS	41.25	Low
Student 2	ALAP	87.50	Tall
Student 3	CASR	73.75	Currently
Student 4	FIU	86.25	Tall
Student 5	KHSK	56.25	Currently
Student 6	SFD	40	Low

The analysis of students' computational thinking levels was based on the results of tests administered after the learning process. Table 4 shows that two students were categorized as high, two students as medium, and two students as low. The researchers further reviewed the findings based on Table 4 through observational data. This was done to gain a more in-depth understanding of students' computational thinking abilities in artificial intelligence-assisted mathematics activities.

The results of observations regarding students' computational thinking abilities in mathematical activities assisted by artificial intelligence, which include the achievement of computational thinking indicators in each CT level category, are presented as follows:

Table2 Observation Results of Students' Computational Thinking Skills in AI-Assisted Mathematics Activities

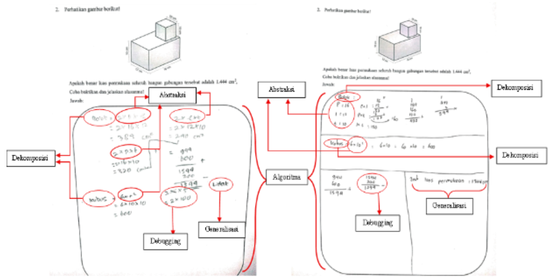
Computational thinking indicators	Student 1	Student 2	Student 3	Student 4	Student 5	Student 6
Decomposition	–	✓	✓	✓	✓	✓
Abstraction	–	✓	✓	✓	✓	–
Algorithm	✓	✓	✓	✓	✓	–
Debugging	–	✓	✓	–	–	–
Generalization	✓	✓	–	✓	–	–

Based on Table 5, the observation data shows variations in achievement for each computational thinking indicator. Students with a high level of computational thinking tend to be able to meet most indicators, including decomposition, abstraction, algorithms, debugging, and generalization. Meanwhile, students with a moderate level of computational thinking demonstrate fairly good achievement of the indicators, but still require guidance from the teacher. Students with a low level of computational thinking show limitations in consistently meeting the computational thinking indicators.

Students' computational thinking abilities in artificial intelligence-assisted mathematical activities show significant differences between individuals. Theoretically, computational thinking involves the processes of decomposition, abstraction, algorithms, debugging, and generalization in solving a problem.(Angeli & Valanides, 2020). Students' computational thinking abilities based on categorization are described more systematically, as follows:

a. High level computational thinking skills

High computational thinking skills enable students to solve math problems in a more structured manner. This is evidenced by the post-test results of students with high computational thinking skills, as follows:

Student 2	Student 4
	

Picture1. Post-Test Results for High Category Students

Based on Figure 1, it can be analyzed that students with high computational thinking skills are capable of decomposition, abstraction, algorithms, debugging, and generalization. These test results are supported by interview data, which states:

“Can you follow the steps given by the AI clearly and copy those steps when solving the math problem?”(**Researcher**)

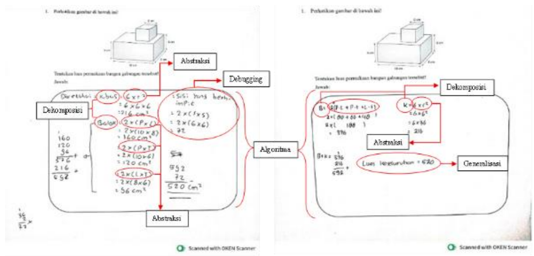
"I'll write in my own language. I'll use AI as a support and rewrite it in my own language."(**Student 2**)

“I will look at the results provided by the AI, then I will copy them based on my own understanding.”(**Student 4**)

Based on this statement, students with high CT abilities tend to be able to develop computational thinking skills and utilize AI assistance as a supporting tool in the thinking process, not as a tool used to obtain answers directly.

b. Intermediate Computational Thinking Skills

Moderate computational thinking ability is characterized by students mastering most of the computational thinking indicators. Generally, students in the moderate category are able to understand the problems presented but still require guidance from the teacher to solve them. The following are the post-test results for students with moderate computational thinking ability:

Student 3	Student 5
	

Picture2. Post-Test Results for Students in the Medium Category

Observations in Figure 2 indicate that students were able to obtain the final answer, but the solution process was not yet fully systematic. Students with moderate computational thinking skills were able to perform decomposition and abstraction, algorithms, but still needed guidance in applying debugging and generalizing the solution strategy to other problems. These analysis results were supported by interview data, which stated:

“Can you see an error that is in the middle of debugging?”(**Researcher**)

"I lack self-confidence because I'm not careful enough, so I often make mistakes."(**Student 3**)

"I lack confidence and still doubt it."(**Student 5**)

Based on this statement, students with moderate computational thinking skills still need guidance in applying debugging to problem-solving. Generalization skills are also rarely seen in students with moderate computational thinking skills. This is reinforced by the following student statement:

“Judging from the results of the test you conducted, did you write a conclusion at the end of your answer?”(**Researcher**)

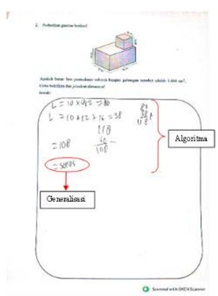
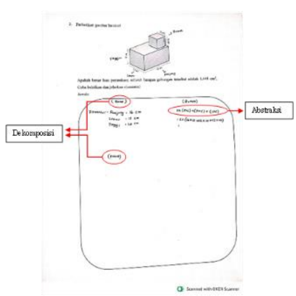
"I sometimes forget, so when I get the results I move on to the next number."(**Student 3**)

"I'm not used to it. Once I get the results, I'll just move on. But if I'm asked to write, I'll write."(**Student 5**)

Based on this statement, it can be concluded that the generalization indicator in students with moderate computational thinking skills still requires guidance. Student respondent 5 was able to apply the generalization because he was instructed to, not because he wanted to. Therefore, the generalization indicator has not yet been fully embedded in students with moderate computational thinking skills.

c. Low-Level Computational Thinking Skill

Computational thinking skills in lower-level students tend to be underdeveloped. Students with low-level computational thinking skills are weak across all indicators.(Faradillah et al., 2025). The following are the post-test results for students with low computational thinking skills:

Student 1	Student 6
	

Picture3. Post-Test Results for Low-Category Students

Based on the visual observation results in Figure 3, it shows that students with low computational thinking skills are unable to solve problems systematically. Students have difficulty identifying the components of geometric shapes, determining the solution steps, and obtaining the final result, so indicators of computational thinking are not yet clearly visible. These analysis results are supported by interview data which stated that:

"Have you tried to work on the problem by breaking it down into parts so that it is easier to work on?"(Researcher)

"I have difficulty breaking down problems into simpler parts."(**Student 1**)

"I have difficulty breaking down problems into simpler parts."(**Student 6**)

"Are you able to solve different problems using the same method?"(**Researcher**)

"I often use the method exemplified by the teacher." (**Student 1**)

"I don't know, sometimes I'm confused."(**Student 5**)

Based on this statement, it can be concluded that students with low computational thinking skills have not been able to fully apply the computational thinking indicators in problem solving. Based on the test results in Figure 3, it can be seen that the work of students 1 and 5 were only able to apply two computational thinking indicators. The achievement of these indicators by the two respondents also differed. Therefore, students with low computational thinking skills still require teacher guidance in developing their computational thinking skills and applying computational thinking indicators in problem solving.

Discussion

The research results show that elementary school students' computational thinking (CT) abilities in artificial intelligence (AI)-assisted mathematics activities fall into the high, medium, and low categories. These differences indicate that CT development does not occur uniformly in all students.Angeli & Valanides (2020)Computational thinking is a problem-solving process that involves the integrated skills of decomposition, abstraction, algorithms, debugging, and generalization. Therefore, the differences in CT levels found in this study indicate variations in students' abilities to integrate these five indicators when solving mathematical problems.

Research findings indicate that students with a high CT category are able to meet all CT indicators. Students can identify the components of geometric shapes, select relevant information, systematically organize solution steps, review their work, and apply learned concepts to new situations. These results align with research.Herlina Budiarti et al (2022) which states that students with high CT abilities are able to integrate decomposition, pattern recognition, abstraction, and algorithms simultaneously in solving mathematical problems. Similar findings were also reported byJunaedi et al (2024)that students with a high CT category are able to fulfill all computational thinking indicators because they have better logical and reflective thinking skills than other categories.

One of the high category students stated that he,

> “don't really like AI because the answers it gives aren't necessarily correct”.

This statement indicates that students don't directly receive information from the AI, but instead evaluate the accuracy of the answers provided. This demonstrates their critical attitude toward the AI's answers. High-level students don't simply copy the AI's answers but rework the information they receive based on their own understanding.

In the moderate category, students demonstrated decomposition, abstraction, and algorithm skills, but were inconsistent in debugging and generalization indicators. This finding indicates that students were able to understand problems and design solution strategies. However, they were not yet fully able to reflect on their own thought processes.Julianti et al (2022), students in the medium category can generally solve problems through the decomposition, abstraction, and algorithm stages, but still have difficulty in generalizing the concepts they have learned.

Statement of the student who admitted,

"Lack of confidence and still doubtful."

When determining whether or not errors were present in problem solving, this indicates that debugging skills in the moderate category are beginning to emerge, but have not yet developed optimally because students still have difficulty identifying errors independently. Therefore, students with moderate computational thinking skills require ongoing practice and guidance from teachers.

Meanwhile, students in the low CT category showed limitations in almost all CT indicators. They experienced difficulty identifying important information, determining problem-solving strategies, and checking their work. These findings support researchKamil et al (2021)which shows that students with low CT abilities tend to have difficulty in analyzing the information needed to solve mathematical problems. ResearchFaradillah et al (2025)also found that low category students were not yet able to integrate decomposition, abstraction, algorithm, debugging, and generalization indicators in a complete manner so that the problem-solving process carried out was still partial.

Students in the lower category tended to still rely on external assistance when debugging the answers provided by the AI. Students stated that

"Unable to find errors when solving problems" This indicates that students experience limitations in applying debugging skills, which makes it difficult for them to solve mathematical problems. This condition indicates that low CT skills are not only related to mastery of mathematical concepts but also to students' limited ability to organize and evaluate their thought processes.

The use of AI in this study provided an engaging learning experience for students because it allowed them to receive immediate feedback when solving math problems. However, the results showed that students' CT abilities influenced how they interacted with the AI. Students with high CT tended to evaluate the answers provided by the AI, compare them with their own work, and then identify any errors in the AI's answers. Conversely, students with low CT tended to accept the AI's answers without further verification. This finding supports the research framework, which states that CT abilities play a role in helping students analyze AI errors and correct misconceptions about mathematical concepts. Furthermore, the results of this study are also in line withSetiawan & Irawan (2025)which states that the integration of AI in learning can have a positive influence on the development of computational thinking because students are encouraged to analyze, evaluate, and reflect on the information obtained.

Furthermore, student interactions with AI demonstrate that technology cannot automatically enhance students' thinking skills. AI merely serves as a tool whose effectiveness is greatly influenced by the user's ability to process the information received. This finding aligns with research.Buton et al (2025)which explains that AI in learning should be used to enrich the learning experience and not as a substitute for students' thinking processes. Therefore, the role of teachers remains essential in guiding students in evaluating the information provided by AI so that the use of technology can optimally support the development of computational thinking skills.

Students' computational thinking skills in AI-assisted mathematics activities demonstrate a combination of systematic thinking processes and intelligent use of technology in learning. Computational thinking in AI-assisted mathematics activities is not simply related to the use of digital devices, but also relates to a way of thinking that emphasizes systematic problem formulation and solution development through the stages of decomposition, abstraction, algorithms, debugging, and generalization. The involvement of AI in learning needs to be designed to encourage active student engagement, adaptive feedback, and simulations that can help students understand concepts more deeply. The use of AI as a collaborative resource for exchanging ideas, conducting initial research, and providing feedback, while students must continue to contribute to higher-order thinking processes such as analysis, evaluation, and synthesis.(Ninghardjanti et al., 2025).

In mathematical activities, particularly on the surface area of a combined rectangular solid (rhythm) and a cube, AI showed an error in adding and subtracting the areas of certain parts. The use of artificial intelligence in mathematical activities is not completely error-free, although the resulting responses appear to be more coherent, logical, and convincing. AI sometimes makes mistakes by providing inaccurate information that is well-packaged and sometimes difficult to detect.(Helal et al., 2024)This shows that the accuracy of the answers provided by AI is not always commensurate with the quality of its presentation.

Thus, students in AI-assisted mathematics activities need guidance so that they do not simply accept AI results as reliable answers, but are also expected to be able to develop computational thinking skills in mathematical activities. Based on the above description, the integration of artificial intelligence in mathematical activities shows significant potential in supporting the development of students' computational thinking skills. AI should be focused on strengthening human thinking capacity, including students' critical and computational thinking skills.

While AI can be used to challenge and expand human thinking, it should not be allowed to usurp or replace critical thinking.(Miao et al., 2024).

Thus, AI should be positioned as a supporting tool capable of enriching the thinking process, not as a replacement for human thinking. In fact, the existence of AI does not threaten students' thinking; instead, errors in AI responses will create a reflective space that encourages students to evaluate, refine strategies, and draw more critical conclusions. Therefore, AI used as a tool for exploration and reflection will not weaken students' thinking skills, but rather strengthen the process of developing analytical and systematic computational thinking in mathematics learning. Teaching and learning related to AI should aim to build core AI competencies that enable students to accommodate new knowledge and adapt to solve problems in new contexts using innovative AI technology.(Miao et al., 2024).

IV. Conclusion

Conclusion

The computational thinking abilities of sixth-grade students show variations in the high, medium, and low categories. These differences are reflected in the achievement of decomposition, abstraction, algorithm, debugging, and generalization indicators in solving mathematical problems, especially on the surface area of composite geometric shapes. Students in the high category are able to integrate all indicators systematically and consistently, students in the medium category are able to fulfill most of the indicators but still require guidance, while students in the low category show limitations in organizing the thinking process in a coherent and reflective manner. In mathematical activities, computational thinking abilities are seen through the way students identify problems, break them down into simpler parts, determine important information, organize solution steps, and review the results of the answers.

This activity demonstrates that computational thinking skills are systematic thought processes that are evident when students encounter math problems. While integrating AI into math activities doesn't directly improve computational thinking skills across the board, it has the potential to become an effective pedagogical tool if utilized appropriately and with teacher guidance. AI serves as an exploration aid, feedback provider, and reflection tool, enabling students to re-examine answers, identify errors, and refine problem-solving strategies.

Errors that arise in AI responses will stimulate students to engage in debugging and in-depth reflection. These errors encourage the development of computational thinking skills in students, enabling them to think critically and correct errors made by AI. Students are expected to be aware of and understand the advantages and limitations of existing AI capabilities.(Miao et al., 2024)Overall, this study confirms that AI-assisted mathematics activities are a strategic tool in developing elementary school students' computational thinking skills, as long as AI is positioned as a learning support medium and not as a substitute for students' thinking processes.

Suggestion

Based on the findings of this study, it is recommended that Teachers place more emphasis on developing students' thinking processes in every mathematical activity, especially by providing space to explain the solution steps, reflect, and draw general conclusions from the problems being solved. Pedagogical assistance for utilizationartificial intelligence so that technology truly functions as a tool to enhance thinking, not just a tool to help with calculations. Examining in more depth the relationship between ability levelscomputational thinking with other variables. Can develop learning designs based oncomputational thinking that is more structured and integrated into the curriculum.

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