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Level of Critical Thinking Abilities of Madrasah Aliyah Negeri 1 Jombang Students in Solving Geometry Problems: A Review Based on Cognitive Style

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Abstrak. Kemampuan berpikir kritis mengacu pada tingkat kecakapan individu dalam berpikir secara kompleks untuk menyelesaikan permasalahan. Penelitian ini bertujuan untuk menggambarkan tingkat kemampuan berpikir kritis siswa Madrasah Aliyah berdasarkan gaya kognitif mereka—baik verbalizer maupun visualizer—dalam menghadapi masalah transformasi geometri. Penelitian dilakukan dengan pendekatan kualitatif deskriptif berbasis studi kasus, dan subjek penelitian dipilih menggunakan purposive sampling, mencakup masing-masing satu siswa dengan gaya kognitif verbalizer dan visualizer. Data dikumpulkan melalui tes dan wawancara, serta diuji keabsahannya menggunakan teknik triangulasi. Data dianalisis dengan tahapan reduksi, penyajian, dan penarikan kesimpulan. Hasil penelitian menunjukkan bahwa siswa dengan gaya kognitif verbalizer mencapai tingkat berpikir kritis level 5, yaitu *The advanced thinker*, yang ditandai dengan kemampuan menjelaskan strategi secara terstruktur dan menduga alternatif penyelesaian, meskipun belum dapat menjelaskannya secara rinci. Sebaliknya, siswa dengan gaya kognitif visualizer berada pada level 4, yaitu *The practicing thinker,* yang ditandai dengan kemampuan menyelesaikan masalah tanpa mampu menjelaskan kembali proses yang dilalui dan belum memahami alternatif penyelesaian lainnya.
Kata kunci: Level Berpikir Kritis, Pemecahan Masalah, Gaya Kognitif *Verbalizer-Visualizer*

Abstract. *Critical thinking ability is the skill level of complex thinking individuals use to solve problems. This study aimed to describe the critical thinking ability of Madrasah Aliyah students with their respective cognitive styles, namely verbalizer and visualizer, in solving geometric transformation problems. This study uses a descriptive qualitative approach with a case study type. The research subjects were selected by purposive sampling, with one student each using a verbalizer and visualizer cognitive style. The data collection techniques used were tests and interviews. The data validity test used in this study was technical triangulation, which was then analyzed by data reduction, data presentation, and conclusion. The results showed that students with a verbalizer cognitive style had level 5 critical thinking ability, namely, advanced thinkers, characterized by students being able to explain strategies coherently and guess alternative solutions but not yet able to explain them. Meanwhile, students with a visualizer cognitive style have level 4 critical thinking ability, namely The practising thinker, characterized by students being able to solve problems but not yet being able to explain what is being done and not knowing the alternative solutions that can be used.*

Keywords: *Critical Thinking Levels, Problem Solving, Verbalizer-Visualizer Cognitive Style*

INTRODUCTION

Students are required to have the ability to obtain, manage, and follow up on information. These abilities include critical, creative, logical, and systematic thinking. The National Council of Teachers of Mathematics (NCTM, 2000) states that in solving mathematical or real-world problems, a person can use reasoning, communication, problem-solving, conceptual understanding, creative thinking, and critical thinking. In line with this opinion, the Ministry of Education and Culture in developing the K-13 Curriculum (2018) also includes critical thinking skills as one of the skills students need in the future and is used to provide educational value, especially in developing abilities.

Elder and Paul (2008) classify students' critical thinking levels as level 1: the unreflective thinker, characterized by students not realizing that there is thinking based on clarity, accuracy, and logic. Level 2: the challenged thinker, characterized by students beginning to understand that they can manipulate themselves in thinking. Level 3: the beginning thinker, characterized by students who have understood that thinking based on clarity, accuracy, and logic can be used consciously. Level 4: The practising thinker is characterized by students' awareness of manipulating their thoughts but not yet having enough skills to monitor their thoughts regularly. Level 5: the advanced thinker, characterized by students' ability to identify their thoughts to master them. Level 6: the master thinker, characterized by students being able to consciously manipulate their thoughts with high-level practical insight.

Critical thinking is intended to be able to think more complexly by using high mental and intellectual abilities. This differs from the general mindset: students only understand concepts without identifying and exploring problems to find further solutions (Amir, 2015; Sari & Suryadi, 2023). There are two dispositions in using critical thinking skills (Ennis, 1996). Firstly, when using their critical thinking skills, students try to find the correct answer that can be proven correctly. In addition, critical thinking skills can be demonstrated when students come up with answers to a problem directly or indirectly.

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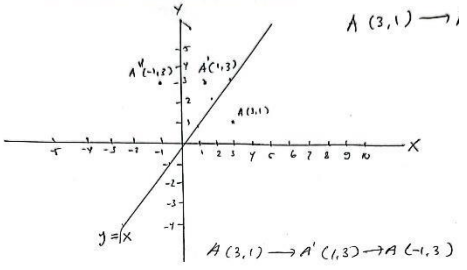
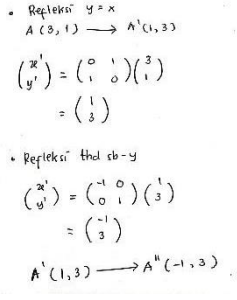
Students use critical thinking skills to interpret, identify, and solve problems. When solving more complex problems, students use their critical thinking skills to solve them, so critical thinking skills are essential (Ocampo, 2018; Zhang, 2015). The importance of problem-solving is also stated in NCTM; problem-solving, reasoning and proof, communication, connections, and representation are the five primary competency standards in mathematics (Mauleto, 2019).

Facione (2011) stated that there are six indicators in the human critical thinking process in solving problems, namely (1) interpretation is an activity in understanding and expressing the meaning of various experiences and classifications of meaning, (2) analysis is the process of determining existing inferential and actual relationships, (3) evaluation is assessing the logical strength of actual inferential relationship statements and other representations, (4) conclusions are taking into account persistent data and reducing the adverse effects of data statements, opinions, and other forms of representation, (5) explanation is the ability to present the results of one's reasoning coherently, and (6) self-regulation is realizing how to monitor one's cognitive activities and using skills such as analysis and evaluation to conduct re-examination.

Based on the results of observations at MAN 1 Jombang, there is diversity in students in solving problems. During the observation, it was found that there were differences in the steps taken by students to solve problems. Some students chose to work using formulas, but some worked on questions by analyzing each question asked. When solving problems, students need complex mental activity skills such as organizing or integrating knowledge. Table following shows students' answers when using images and formulas in Table 1.

Table 1. Differences in students when solving the problem

Students' answers using pictures	Student answers using formulas
	

Cognitive style is a person's consistent method of remembering, thinking, solving problems, responding to tasks, and capturing stimuli or information (Agoestanto et al., 2016; Hasan, 2019). According to McEwan & Reynolds (2007), two cognitive styles are related to a person's habits in using their senses: visualizer and verbalizer. A person with a visualizer cognitive style tends to be easier to receive, process, store, and use in the form of images and graphics. A person with a verbalizer cognitive style tends to be easier to receive, process, store, and use in text or writing (Sintiya et al., 2021). The appropriate material to find out how students use their critical thinking skills using their cognitive style is solving geometry problems (Suwito, 2024; Winarso & Dewi, 2018).

Research by Widodo and Widya (2017) shows differences in students' critical thinking with verbalizer and visualizer cognitive styles in solving geometry problems. Students with visualizer cognitive styles excel in three areas of critical thinking: providing direct explanations, developing basic skills, and organizing strategies and tactics. Students who use verbalizer cognitive styles can identify relevant and irrelevant aspects of a problem by mentioning all relevant details. Verbalizers usually sort information according to what is known about the problem. Students with verbalizer cognitive styles excel in two areas of critical thinking: concluding and providing additional explanations. This study is 1) to determine the critical thinking ability of Madrasah Aliyah students with a verbalizer cognitive style in solving transformation geometry problems. 2) to determine the level of critical thinking of Madrasah Aliyah students with a visualizer cognitive style in solving transformation geometry problems. The benefits of this study are that it provides an overview of students' critical thinking abilities when solving mathematics problems using verbalizer and visualizer cognitive styles. This study's findings can be used to measure how well students learn mathematics, allowing teachers to adjust instructions to students' verbalizer and visualizer cognitive styles.

RESEARCH METHOD

The research method used is descriptive qualitative research with a case study approach. The research was conducted at MAN 1 Jombang, and the research subjects were students of class XI MIA 5, who were screened through verbalizer and visualizer cognitive style tests. The research instruments consisted of researchers as key

instruments, cognitive style tests adapted from the Verbalizer-Visualizer Questionnaire by Mendelson (2004), geometry problem-solving tests, and interview guidelines. The following are indicators of the test instruments used; some subskills must be met for each indicator, as presented in Table 2.

Table 2. Critical Thinking Ability Subskill Indicators

Aspek	*Sub Skill*	Kode
Interpretation	Categorization	I_1
	Code breaking	I_2
	Clarification of meaning	I_3
Analysis	Checking out ideas	A_1
	Detecting arguments	A_2
	Argument analysis	A_3
Evaluation	Evaluate the truth	E_1
	Assessing the quality of arguments using inductive and deductive reasoning	E_2
Conclusion	Proving the question	K_1
	Guessing alternatives	K_2
	Interesting conclusion	K_3
Explanation	Explaining methods and results	P_1
	Allow the procedure	P_2
Self Regulation	Self-examination	R_1
	Self-correction	R_2

Based on the indicators and levels of critical thinking from the theories of Elder and Paul (2008) and Facione (2011), the following is the relationship between the two theories used to determine students' levels of critical thinking, which is presented in Table 3.

Table 3. Critical Thinking Levels

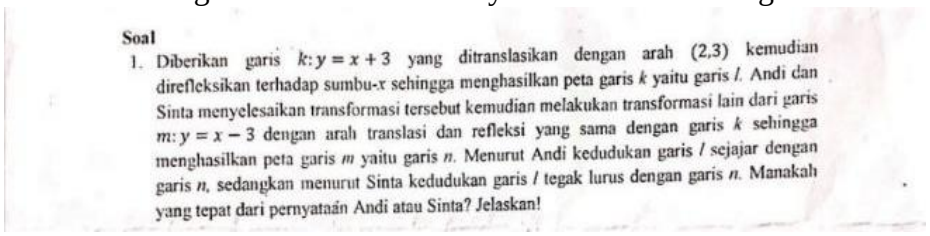
Critical Thinking Levels	**Critical Thinking Indicators**					
	Interpretation	**Analysis**	**Evaluation**	**Conclusion**	**Explanation**	**Self Regulation**
Level 1: *The Unreflective Thinker*	✓					
Level 2: *The Challenged Thinker*	✓	✓				
Level 3: *The Beginning Thinker*	✓	✓	✓			
Level 4: *The Practicing Thinker*	✓	✓	✓	✓		
Level 5: *The Advanced Thinker*	✓	✓	✓	✓	✓	
Level 6: *The Master Thinker*	✓	✓	✓	✓	✓	✓

Data collection techniques based on Miles and Hubberman (1984) include data reduction, data presentation, and conclusion. Data validity techniques are carried out with observer diligence and triangulation techniques by combining written test results, thinking aloud, and subject interviews to obtain valid data. In this study, subjects were screened through the distribution of VVQ (Visualizer and Verbalizer Questionnaire). In addition to the subjects' answers, the researcher used the think-aloud method and semi-structured interview instruments to support the subjects' answers in completing the tests given. Based on the classification of cognitive styles, the researcher then asked for help from the mathematics subject teacher to provide recommendations for students who met the criteria to become research subjects. Six students were selected as research subjects consisting of 3 with a verbalizer cognitive style and three with a visualizer cognitive style to determine the tendencies of research subjects with their respective cognitive styles. However, the researcher reported and described two research subjects representing each cognitive style. The following data on the research subjects to be analyzed are shown in Table 4.

Table 4. Research Subject Data

Num.	Student	Cognitive Style	Subject Code
1.	RAR	*Verbalizer*	M1
2.	GFS	*Visualizer*	M3

In implementing the research, the material used is geometric transformation material. The following shows the test used by the researcher in Figure 1.


Soal

1. Diberikan garis $k: y = x + 3$ yang ditranslasikan dengan arah (2,3) kemudian direfleksikan terhadap sumbu-x sehingga menghasilkan peta garis k yaitu garis l. Andi dan Sinta menyelesaikan transformasi tersebut kemudian melakukan transformasi lain dari garis $m: y = x - 3$ dengan arah translasi dan refleksi yang sama dengan garis k sehingga menghasilkan peta garis m yaitu garis n. Menurut Andi kedudukan garis l sejajar dengan garis n, sedangkan menurut Sinta kedudukan garis l tegak lurus dengan garis n. Manakah yang tepat dari pernyataán Andi atau Sinta? Jelaskan!

Figure 1. Critical Thinking Level Test Instrument

Each subject worked on one question. The researcher gave the question, and then the subject was asked to work on it. After completing the questions, the researcher conducted an interview that was still related to each subject's test answers. The data was recorded using a recording device to make it easier for the researcher to understand and analyze the test and interview results. In addition, the researcher also documented the test or interview with the help of others.

RESULTS AND DISCUSSION

RAR Subject with Verbalizer Cognitive Style (M1)

Analysis of M1's critical thinking skills in solving geometry problems based on the following critical thinking indicators:

1) Interpretation

According to the written test answers, M1 did not write down which parts were known and asked clearly. However, M1 could mention the parts known and asked in the test. This is shown through the results of M1's think-aloud as follows:

"Given line k, its equation is line y=x+3 translated in the direction (2,3) then reflected in the x-axis to produce line l. Andi and Sinta complete the transformation and then another transformation of line m, whose equation is y=x-3 with the same translation and reflection directions as line k to produce line n."

2) Analysis

According to the written test answers, M1 did not show the concepts used, but M1 could have mentioned what concepts were used in the test. M1 could also guess clear and sequential steps before answering the question but could not clearly show the guesses occurring when the concepts were connected. This can be shown through the results of M1's think-aloud as follows:

"...means the first y=0, x is -3. So (-3,0). Means -3+2=-1.0+3=3. So the first result is (-1,3). Then reflected with the x-axis so that the y changes to (-1,-3), the second point (0,3) plus (2,3) is equal to (2,6) then reflected with the x-axis so that the y changes to (2,-6), the equation of the line m,(3,0) is the same as (0,-3). So, (3,0) plus (2,3) is the same as (5,3) if reflected on the x-axis then multiplied by (0,1,0,-1) so the y changes to (5,-3), then the second point, namely (0,-3) plus (2,3) is the same as (2,0) then reflected on the x-axis then the y changes to the same as because the y is zero so it remains (2,0)"

3) Evaluation

M1 was rechecked by reading it repeatedly before proceeding to the next step. This is supported by the results of the M1 interview as follows:

P: "When you do this, how do you ensure the answer is correct?"
M1: "Recheck it, Ma'am; you must look at the dots again for the picture."

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Furthermore, M1 also completed the test by writing it sequentially from beginning to end with the correct answer results so that it was stated that M1 completed the problem with the deductive solution. This can also be shown in Figure 2.

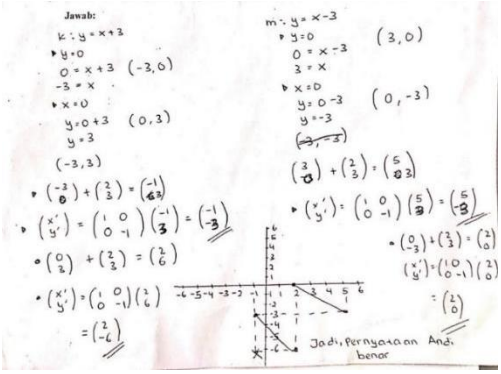

Figure 2. M1 Writing the Answer from the Known Part Until Finding the Answer

4) Conclusion

M1 writes the final result in the answer (Figure 4.2 section M101) and shows it in the think-aloud results as follows.:

> *"Now draw the k (-1,-2) and (2,-6). This is the first line, followed by the second (5,-3),(2,0). From the drawing results, it can be concluded that Andi's opinion that the line's position is parallel to line n is correct."*

Furthermore, M1 can predict other alternatives that can be used to solve the problem. The following interview results show this:

> *P: "Apart from using this method, do you know any other methods?"*
> *M1: "The alternatives, the first one is definitely like this. The second is a reflection on the x-axis, which can be done quickly without multiplication as the y-axis will change."*

5) Explanation

M1 was able to explain the answer verbally again. M1 also made corrections to ensure that the final answer to the test was correct. The following interview results show this:

> *P: "Can you explain again how to do this?"*
> *M1: "First, we look for the important point; that is the point, right? It is a line, so there must be two points from the k-line: x = 0 and y = 0. After that, we get two points. After that, each point is translated and reflected."*

6) Self-regulation

When conducting the interview stage, M1 stated that he could not explain the calculation of other alternatives for completing the test in detail. M1 only rechecked the answers written on the test sheet.

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GFS Subjects with Visualizer Cognitive Style (M3)

Analysis of M3's critical thinking skills in solving geometry problems based on the following critical thinking indicators:

1) Interpretation

According to the written test answer, M3 only wrote the initial part of the equation to be translated without providing further information. However, in the think-aloud results, M3 could mention the parts that were known and asked for in the test. This is shown through the results of M3's think-aloud as follows:

"y = x+3, for example x=0 then y = 0+3, y is the same as 3. We assume y = 0, then 0 = x+3, so -3 = x, and the coordinates are the same as (0,3) and (-3,0), then we make a line…"

2) Analysis

The written test answers show that M3 did not show the concepts used. However, M3 can mention what concepts are used in the test. This is shown through interviews conducted by researchers with subjects as follows:

P: "How did you create a solution strategy?"
M3: "I was confused at the beginning, but after calculating the initial line, it turned out to be correct. I used this as a reference for the next work."
P: "What about the picture?"
M3: "I think it is correct because the calculation is correct."

3) Evaluation

M3 also completed the test by writing it sequentially from beginning to end by giving a sign of the sequence of steps and the correct answer results so that it was stated that M3 completed the problem with a deductive solution, and the conclusion was that Andi's statement was correct. This can be shown in Figure 3.

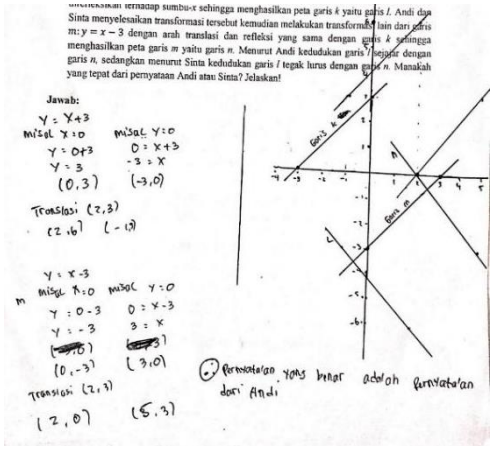

Figure 3. M3 Completes the Test with Coherent Answers

4) Conclusion

M3 can mention the final result and can predict alternative answers that can be used. The following interview results show this:

P: "You did it using one picture at a time, right? You looked for the point first. So, do you think there is another way besides using pictures?"
M3: "I think there is, but I have not been taught, or I forgot."
P: "So what is the conclusion of your answer?"
M3: "The correct statement is Andi's statement where line l is parallel to line n."

5) Explanation

Based on the written test answers, M3 could explain the answers verbally again. M3 also made corrections to ensure that the final answer to the test was correct. However, M3 did not write down the initial formula used when working on it. M3 only worked on the test using a picture of what to do but did not include it on the answer sheet shown in Figure 4. In addition, M3 also initially seemed confused when drawing points on the coordinates of the line.

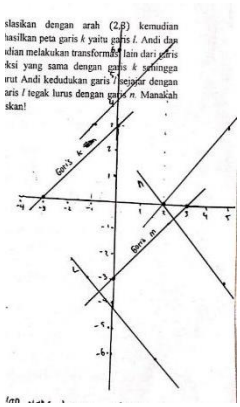

Figure 4. M3 Answering Questions Using Images from Translation to Reflection

6) Self-regulation

When conducting the interview stage, M3 stated that he did not know other alternatives to complete the test. M3 did not recheck the answers on the test sheet and immediately decided that the answers he had worked on were correct. The following interview results also support this evidence:

P: "Didn't you correct this again?"
M3: "I already corrected it at the beginning when I was working on it, Ma'am."

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Each subject's critical thinking ability indicators are classified according to their level in Table 1, presented in Table 5.

Table 5. Indicators Fulfilled by Subjects

Subject	Indicator																Level
	Interpretation			Analysis			Evaluation		Coclusion			Explanation			Self Regulation		
	Subskill																
	I_1	I_2	I_3	A_1	A_2	A_3	E_1	E_2	K_1	K_2	K_3	P_1	P_2	P_3	R_1	R_2	
M1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	✓	5
M3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-	-	4

A brief description of the critical thinking ability of students with visualizer and verbalizer cognitive styles is shown in Table 5.

Critical Thinking Ability Level of Students with Verbalizer Cognitive Style

Critical Thinking Levels	
Level 5: The advanced thinker	*Level 4: The practising thinker*
Students with a verbalizer cognitive style: Students can think further with a broader knowledge of the given problem. Students can also explain the strategy that will be carried out coherently. Students can guess alternative solutions but are not yet able to explain these alternatives, so students only apply this knowledge to all problem-solving.	Students with a visualizer cognitive style: Students know that a problem must be solved, and students can solve it correctly. However, students have not been able to explain what is being done again, so they do not know the knowledge used in depth. Students more often use pictures to make the work easier. In addition, students are also unable to show other alternative solutions that can be used and do not make corrections to all the answers that have been written.

Based on Table 3 below, evidence supports students' critical thinking skills with a verbalizer cognitive style at level 5; students can think further with a broader knowledge of the problems given. Students can also explain the strategies that will be carried out coherently. However, students have not been able to apply this knowledge to all problem-solving, as indicated by the subject's inability to guess and explain alternative solutions.

Students with a verbalizer cognitive style tend not to write down the parts that are worked on clearly, but students can clearly describe the steps to solve them. This is in line with the results of previous studies, namely that students with a verbalizer cognitive style can provide solutions in words (Djawa et al., 2022). In their writing, students also tend to be more coherent and transparent toward the conclusion of problem-solving. Research shows that students understand all information presented verbally and can identify what is known and ultimately asked of them (Septyani & Siswono, 2018). Students with a verbalizer cognitive style can also determine the steps to solving problems only with the right strategy in planning (Hasan, 2019; Mulyati, 2019).

However, in solving the problem, students do not know other ways or alternatives that can be used. Students are only fixated on one teaching method applied to solve the problem. This aligns with the results of research from Fatmawati et al. (2014) and Arwadi et al. (2024). In problem-solving, students tend to solve it using one method without paying attention to or knowing other methods, so they only recheck the results of their solutions. From this description, students with a verbalizer cognitive style have critical thinking skills at level 5, namely the advanced thinker.

Critical Thinking Ability Level of Students with Visualizer Cognitive Style

Based on the research results, the following is a presentation of student's critical thinking skills with a verbalizer cognitive style at level 4. Namely, students know that a problem must be solved and that they can solve it correctly. However, students have not been able to re-explain what is being done, so students do not yet know in depth the knowledge used. Students more often use pictures to make the work easier. In addition, students are also unable to show other alternative solutions that can be used and do not make corrections to all the answers that have been written.

Students with a visualizer cognitive style also tend not to write down what is known in the question and do not explain the steps on the answer sheet that is being worked on. This is in line with the results of previous studies, namely that students with a visualizer cognitive style tend to describe or rely more on their imagination in the form of visual objects such as illustrations (Mulyo et al., 2019; Sintiya et al., 2021). Students prefer to use images directly on the Cartesian coordinate plane to show their solutions. This makes it difficult for students to explain verbally what has been done in sequence.

Students have difficulty showing the steps of the work if they do not use images. This is supported by research that shows students cannot re-explain the problems being solved and find it easier to understand the problem if they use images (Habibi et al., 2020; Novitasari et al., 2021).

Similar to students with a verbalizer cognitive style, students also do not know other alternatives that can be used to solve the problem. Students also tend to use one method that has been taught, which is then applied to solve the problem. This is in line with research showing that students with a visualizer cognitive style also tend to solve problems using one method without paying attention to or knowing other methods so that students only recheck the results of their solutions (Fatmawati et al., 2014). From this description, students with a visualizer cognitive style have critical thinking skills at level 4, namely the practising thinker.

CONCLUSION

Students with a verbalizer cognitive style have critical thinking skills level 5, namely The advanced thinker, which is characterized by students being able to explain strategies coherently and guess alternative solutions but not yet able to explain them. Meanwhile, students with a visualizer cognitive style have critical thinking skills level 4, namely The practising thinker, characterized by students being able to solve problems but not yet being able to explain what is being done and not knowing the alternative solutions that can be used. Suggestions for educators are expected to be able to provide problem-solving that is used to train students' critical thinking skills and are accustomed to providing various alternative solutions to solving one problem.

Suggestions for other researchers to develop learning media to improve or utilize students' critical thinking skills. In addition, subsequent research can examine students' critical thinking skills when viewed from other cognitive styles.

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