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RESEARCH ARTICLE

The Analysis of Students' Critical Thinking Ability with Visualizer-Verbalizer Cognitive style in Mathematics

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ABSTRACT

This study aimed to describe the process of critical thinking of students in solving mathematical problems in algebraic viewed from the differences in cognitive styles-Verbalizer Visualizer. The description of the thinking process was based on Polya's problem-solving indicator namely understanding the problems, developing plans, implementing problem-solving activities, and to re-examining the results obtained. The research instrument includes the researcher himself, tests of cognitive style, problem-solving task, and the interview guideline. The data analysis was performed by means of data reduction, data presentation, interpretation of data, and drawing conclusions. The study concluded that the visualizer subject disclosed the acknowledged information and asked to use the images and algebraic notation, used a variety of strategies to solve problems, performed calculations by taking into account the things we need and recheck the answer in detail. Verbalizer Subject, however, was able to disclose the acknowledged information and questioned using mathematics formula without using pictures and notation. In terms of making plans for the completion, the subject merely used one step-finishing process. In determining the final outcome, verbalizer subject rechecked every step of the finishing by recalling and paying attention to the proper answers.

1. INTRODUCTION.

In the ease of math problems, students are often faced with difficulties such as; (1) not being able to plan step processes, (2) not being able to write a mathematical formula in accordance with what is acknowledged. Sepcifically, at the stage of carrying out the plan, it goes to; (1) not using a mathematical concept well in the calculation process (Hasan, 2016).

Through the learning of mathematics in the school the student is expected to have the ability to think logically and critically which is useful when students study other science. If this thinking skill is trained, it will facilitate and expedite the learner in solving a problem well. According to Alemi (in Behl and Ferreira, 2014) thinking is the ability to recognize, to understand, and to synthesize interaction, and to be interdependent in a component designed for a specific purpose.

The purpose of critical thinking is to achieve a deeper understanding. With a deep understanding of a person will be able to reveal the meaning behind the information obtained in order to find the truth in the midst of the many informed and able to make the right decision in every action. According to Johnson (2009) critical thinking is an essential capability that must be possessed by learners both in solving problems, making decisions as well as considerations to take action, so that will get the results .If this thinking skills are trained, it will facilitate and expedite the participants learners in resolving a problem well.

In addition to critical thinking, it is also said that one of the goals of learning mathematics in school is students possess the ability to solve problems. In studying mathematics, they are required high ability to think and to reason. One important component in mathematics needed high thinking skill among students is a process to solve the problem (Hasan, B. 2016). Problem solving is a focus in mathematics. Polya (1973) suggests four steps to be taken, namely: 1) understanding the problem, 2) devising a plan, 3) carrying out the plan, and 4) looking back. Students can obtain optimal results and benefits of the solution when it is done through organized solving steps.

In solving mathematical problems as well as problems encountered in everyday life, each individual has a different way of solving it. This is because each individual has different characteristics, especially in acquiring, storing, and using the information received. Students' ability to solve problems is important. In terms of problem solving, the problem of students require the ability of complex mental activity, not only requires memory for facts, a wide variety of skills, and procedures at their disposal, but also organizing or integrating knowledge. How a person processes, stores, and uses the information to respond to a task is called cognitive style. Different cognitive style is likely to affect way or strategy in solving problems encountered.

According to McEwan (2007), cognitive style associated with the habit of using the students' senses is divided into two groups, namely visualizer and verbalizer. The discrepancies between the visualizer and verbalizer cognitive style are caused by the difference of one's views in describing something. Someone with a visualizer cognitive styles tends to be easier to receive, process, store, and use the information in the form of images, whereas a person with a verbalizer cognitive style tends to be easier to receive, process, store and use the information in the form of text or writing.

In connection with math in school, algebra is one material taught to students, especially in Junior High Schools. Such material is significant because many mathematical concepts are demonstrated with the help of the language of symbols in algebra. When asked to solve algebra problems, one must think harder to understand how a quantity (number) is generalized (formulated) in the form of symbols in the form of letters, the relationship between symbols, and manipulation of these symbols. Many problems in everyday life that can be simply solved by the language of symbols in algebra makes it important to learn. In this case, a person is required to think critically to understand the context of the problems, evaluate any logical reason at every step, making inferences and assessing each step in the troubleshooting process. Therefore, the algebra problems will be more demanding on problem solving for critical thinking.

According Sieger (in Ngilawan, 2013: 72), it is stated that thinking is information processing. This means that when an individual feels, does the encoding, presents, and stores information from the world around them is considered doing the thinking process. In addition, Siswono (2008) states that thinking is a mental activity that a person experiences when they were faced with a problem or situation to be solved.

The process of thinking is defined by Dewey (in Ning, 2011) that essentially, critical thinking is an active process to think about things more deeply to ourselves, asking questions to ourselves, to find relevant information for ourselves than to receive things from other people. However, the most important thing from the definition of Dewey is the things that become reasons to believe in something. Then the definition developed by Edward Glaser (in Fisher, 2008) defines critical thinking as:

Seifert & Hoffnung in Desmita (2011) mentions some critical thinking components as follows:

1. Basic operation of reasoning, to think critically, a person has the ability to explain, to generalize, to draw deductive conclusions, and to formulate logical steps.
2. The specific knowledge domain, in the face of a problem, one must have knowledge about the topic or content. To resolve a personal conflict, one must have knowledge of the person and with whom he/she owns the conflict.
3. Metacognitive knowledge, the effective critical thinking requires someone to monitor when he tries to really understand an idea, to be aware when he needs new information, and to predict how it can easily collect and study the information.
4. Values, beliefs and dispositions, critical thinking means to assess fairly and objectively. This means that there is a kind of confidence that the thought really lead to a solution. It also means there are some sort of persistent disposition and reflection while thinking.

Based on the notion of learning outcomes above it can be concluded that the process of critical thinking in this research is the mental activity in solving algebra problems towards a conclusion based on the evidence, valid source of information, as well as a reasonable explanation.

a. Cognitive style

Smith (2010) suggests that the cognitive styles refers to an individual preferred way to process information. As for Uno (2008), cognitive style is distinctive in the way students learn, both with regard to how the reception and processing of information, attitudes towards information, and practices related to the learning environment. Based on the description above, it can be concluded that cognitive style in this study is the way a person to receive, to process, to store and to use the information to respond a task or various types of environmental situation.

1. Visualizer Cognitive Style

Mendelson (2004) explains that individuals who have visualizer cognitive style tend to be more in pictures, being more smoothly with illustration and translation, as well as understanding and loving visual games, like a puzzle. From the description above, it can be concluded that visualizer cognitive style in this study is the tendency of a person to capture the information of what they saw, so they are easier to receive, to process, to store and to use the information in the form of images.

2. Verbalizer Cognitive style

Mendelson (2004) explains that individuals who have verbalizer cognitive style is more likely to say, and prefers to communicate with someone by showing how they do it. From the description above, it can be concluded that visualizer cognitive style in this study is the tendency of a person to capture the information of what they hear, so they are easier to receive, to process, to store and to use the information in the form of text or writing.

3. Measurement of Cognitive Style

In this study, the cognitive style of students is identified through the implementation of Cognitive Style Classification Test Visualizer-Verbalizer (TGK) to each of the research subjects. This test was adapted from Mendelson (2004) that the Visualizer and Verbalizer Questions (VVQ) in an article entitled "For Whom cognitive style and attention on Processing of New Photos"

In this research, the instrument consists of 20 items of statements that lead to verbalizer and visualizer cognitive styles. Each student is required to select a statement in accordance with their respective characteristics. Criteria grouping cognitive styles can be seen from the acquisition of scores of the students' each cognitive styles. If one of the cognitive style obtains the highest score, it means that students have a tendency towards the cognitive styles. For example, if a student scores on visualizer cognitive style higher than with verbalizer cognitive style, it means the student has a visualizer cognitive style.

2. RESEARCH METHOD

This type of research is descriptive research with a qualitative approach to identify students' critical thinking process in solving algebraic forms in terms of the difference-Verbalizer-Visualizer learning styles. The critical thinking process identified in this study is based on Polya's measures of critical thinking.

The subjects were students of class 8 SMPN 1 Bangkalan, who have verbalizer-visualizer learning style. The criteria for subject selection is through the students' highest score in a verbalizer

visualizer learning style. So, the subjects in this study consists of one student who has the highest visual learning style, and one student who has the highest verbal learning style.

Table 1 Criteria Subjects Research

Number	Subject	Age	Mathematical ability	Cognitive style
1	S1	14	80	Visualizer
2	S2	14	75	Verbalizer

The instruments of this study are described as follows: 1) The researcher; Sugiyono (2013) explains that the researcher is a key instrument in qualitative research. It serves to determine the focus of research, to pick a subject, to collect data, to assess data quality, to analyze data, to interpret the data and to make inferences which can be done properly, 2) Test of Cognitive Style (TCS) which consists of 20 statements adapted from Mandelson (2004). 3) Problem Solving Assignment (PSA), which consists of 2 algebra problems, and 4) Guidelines for the interview of Polya's problem solving steps.

According to Siswono (2002), observing the process of thinking can be done through the process of how to take the test, and the results are written in sequence. Also, it is coupled with in-depth interview about how it works. Thus, the data collection techniques in this study is to observe the process of students' critical thinking in solving problems of the story form by giving the test solving on the subject, and conducting in-depth interview using the interview guide to the subject of the work of problem-solving tests. Besides that, it is necessary to administer the observation of the critical thinking process. Observations made by the researcher were based on Arikunto (2006) that the observations could be done through tests, questionnaires, image records, or sound recording.

Data analysis was done through the stage of data classification, data reduction, presentation of data, interpretation of data, and conclusion. One technique for examining the credibility of the data is through triangulation (Sugiyono, 2013). The triangulation used is the techniques including interviews and observation of the subject's work in problem-solving test.

3. RESULT AND ANALYSIS

Based on the results of learning style test given to students in grade VIII-F SMPN 01 Bangkalan, it is obtained a fact that the type of student learning styles in solving algebra problems can be categorized into verbalizer and visualizer cognitive style. As for the students who have the visualizer cognitive style is more dominant than the students who have the verbalizer cognitive style. It can be found that the number of students who have the visualizer cognitive style is as many as 16 students, with the total of 2 students with verbalizer cognitive style and the rest is as many as 18 students have the verbalizer and visualizer cognitive style.

Based on the analysis that has been done appears that the critical thinking process visualizer subject and verbalizer have differences in the process of understanding the problems, developing plans remedy problems, carrying out problem-solving plan, and rechecking the results obtained.

a. Understanding the problem

Identifying the acknowledged information and things that are asked in the questions.

1) Visualizer subject

Table 2. The triangulation of Visualizer Subject Data in Understanding the Problem

Problem-solving Test 1	Problem-solving Test 2
Writing and mentioning information what is acknowledged and asked.	Writing and mentioning information what is acknowledged and asked
Estimating if the data provided have been adequate to solve the problem contained in the question.	Estimating if the data provided have been adequate to solve the problem contained in the question.
Using the appropriate notation to reveal the known and asked variables	Using the appropriate notation to reveal the known and asked variables
Explaining the subject matter contained in the problem-solving test 2 to which means that S1 revealed the contents not with their own words.	Explaining the subject matter contained in the problem-solving test 2 to which means that S1 revealed the contents not with their own words.
Using the images to understand the problem better.	Using the images to understand the problem better.

Based on validity finding of the data analysis on table 2, it can be concluded that the visualizer subject can be explained as follows:

- the subject can identify the information known and asked appropriately, identify the adequacy of the data to solve problems, and express what is known and asked in pictures
- Subjects create images and algebraic notation to disclose the information received.
- Subjects cannot recall information in their own language except by reading the question.

2) Verbalizer subject

Table 3. The Triangulation of Verbalizer Subject Data in Understanding the Problem

Problem-solving Test (TPM) 1	Problem-solving Test (TPM) 2
Interpreting the questions in their own words.	Interpreting the questions in their own words.
Estimating if the data provided have been adequate to solve the problem contained in the question.	Estimating if the data provided have been adequate to solve the problem contained in the question.
Using the appropriate notation to reveal the known and asked variables	Using the appropriate notation to reveal the known and asked variables
Could not create an image in stating what is known and questioned.	Could not create an image in stating what is known and asked

Based on Table 3, it can be explained that the verbalizer subject as follows:

- Subject mentioned what was known, i.e. the size ratio of the pool, circumference, and the road additional costs.
- Subjects were asked to mention the total cost required to make the road.
- Subjects could not make image in illustrating information received.
- Subject revealed the information in his or her own language.

b. Making Problem-solving Plans

(Determining the steps to solve the problem based on the information already known).

1) visualizer subject

Table 4. The triangulation of Visualizer Subject Data in Making Problem-solving Plans

Problem-solving Test 1	Problem-solving Test 2
Developing a plan for problem solving by using images and algebraic notation to find the result of width and length value.	Developing plan for problem solving by using images and algebraic notation to find the result of width and length value.
Developing a plan for problem solving in other ways, namely using the ratio formula to find of length and width values.	Developing a plan for problem solving in other ways, namely using the ratio formula to find of length and width values.
Obtaining idea to calculate the area of road by saying a total area is reduced by pool's surface area.	Obtaining idea to calculate the area of road by saying a total area is reduced by pool's surface area.

Based on table 4 above, it can be explained that the visualizer subjects in making problem solving plans are described as follows:

- The subject used algebraic perspective and an image by selecting the appropriate notation as well as being able to choose the right formula in solving algebra problems. In this way, what the students knew was not only conceivable in his mind but also presented on the paper.
- The subject used logical perspective using a comparison formula to find the value of length and width. The subject ignored things that were less related to the problem solving.

2) Verbalizer subject

Table 5. The Triangulation of Verbalizer subject Data in Making Problem-solving Plans

Problem-solving Test 1	Problem-solving Test 2
The subject planned a problem solving strategy using logical thinking by using the appropriate notation and was able to choose the right formula to solve the problem	The subject planned a problem solving strategy using logical thinking by using the appropriate notation and was able to choose the right formula to solve the problem
The subject determined the steps or planning a problem solving by trying the substitution method to find the value of the length and width.	The subject determined the steps or planning a problem solving by trying the substitution method to find the value of the length and width.
The subject determined the idea to solve the problem by saying a total area is reduced by section area.	The subject determined the idea to solve the problem by saying a total area is reduced by section area.

According to table 5, it can be explained that the verbalizer subject in planning problem solving is described as follows:
The subject used logical thinking using ratio formula to find the result of length and width values.
The subject ignored things less related to the problem solving.

c. Implementing Problem-solving Plans
(Subject processed and recalled the information, so that the subject can solve the problems.)

1) Visualizer subject

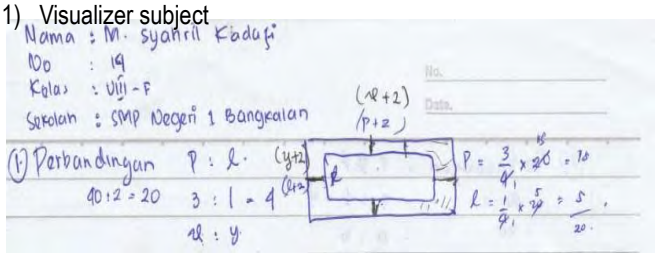

Figure 1. Results of Visualizer Subject's Work

Subject was able to create an image. The image was used to determine the size of the subject and an extra measure of road construction by using supporting variables in determining the steps to solve the problem.

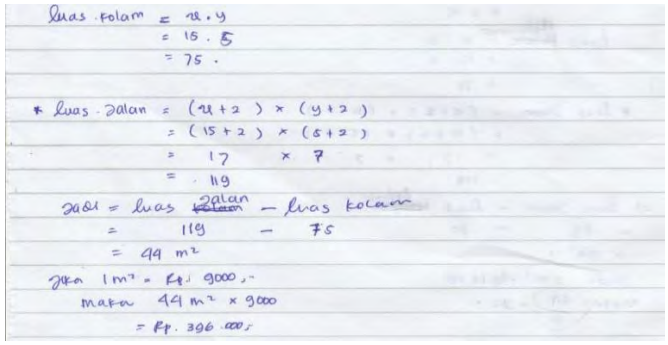

Figure 2. Results of Visualizer Subject's Work

Subject resolved the problem by using algebraic notation precisely and thoroughly.

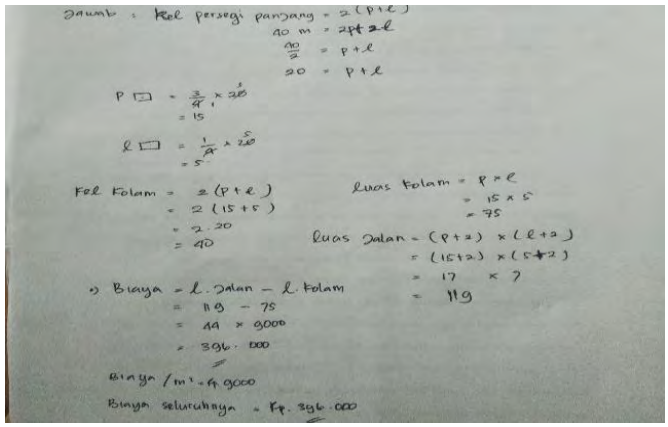

Figure 3. Results of Visualizer Subject's Work

Subject resolved the problem with other ways, i.e. using comparison formula to solve the problem

Based on the research, it can be said that

a. Visualizer subject was able to write the result in accordance with the plan made before precisely and correctly. Firstly, he used algebraic thinking and pictures, which both used a logical way of thinking by making comparison and if formula.
b. Visualizer subject was able to do the question with focus and attention to the important things needed in solving the problem.

Verbalizer subject

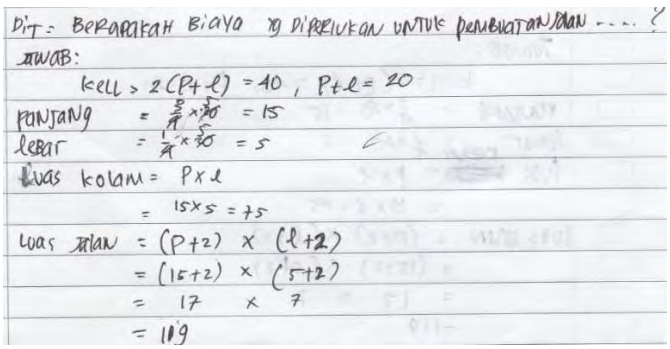

Figure 4. Results of Verbalizer Subject's Work

Based on the results of validation that S2 showed some of the same things in the understanding of the problem as in interviews Problem Solving Test 1 and Problem Solving Test 2. It can be seen in implementing problem-solving plan, S2 recalled concepts, facts, and procedures by recalling previously known information. In other words, the subject was able to write down what was known (comparison and circumference of pool), asked (the cost of the road), and the process of answering the question. Subject explained the symbols which he wrote as p, l, p + 2, and l + 2 correctly on the answer sheet despite a few error in writing multiplication operation and the sum. Subject worked on the problem with the lack of focus, so that few errors were found on the results.

Based on interviews and verbalizer subject's work, it can be explained as follows:

- Subject wrote completion according to plan he had made precisely and correctly, i.e. only using logical thinking strategies and formulas to make comparison.
- Subject worked on the problems with less focus so that she forgot important things needed in solving the problem.

d. Rechecking

Evaluating the problem solving steps from the beginning to the end.

1) Visualizer subject

Towards the rechecking of the results, it can be seen that the S1 made an evaluation on each of the steps, i.e. understanding the problem, devising a plan, problem-solving and problem solving by examining the question and recounting the obtained answers. Subject also performed checks on the suitability of the answer to what was known and asked. Subject was able to compare that the calculation results obtained before and after the calculation was examined remained the same. Finally, it can be concluded that the results obtained are correct.

- So it can be concluded that the subject conducted a check toward the results obtained by evaluating the steps from the beginning to the end and compared the responses before and after Subject evaluated the problem solving steps starting from understanding the problem, organizing, and solving the problem, by rereading the problem and calculating the answer again.
- The subject also concluded that the two used strategies produced the same answer and after rechecking, the results remained the same.

Examination by rechecking and paying attention to the answers to the problem.

2) Verbalizer subject

It can be seen that the subject believed that the steps taken were correct and in accordance with the existing problems in the question because the subject conducted the answer examination in the steps of understanding the problem, planning, implementing problem solving plan, and problem resolution. Subject concluded that the calculation results obtained before and after examining the calculation results remained the same. Subjects also performed checks on the suitability of the answer to what was known and asked. In addition, subject re-examined all the things done from beginning to the end by recalling the question and paying attention to the answer.

So it can be concluded that subject checked the results obtained by evaluating the steps from the beginning to the end and compared the responses before and after being examined by recalling the question and paying attention to the answers to the problem.

Subject evaluated problem solving steps comprising understanding the problem, rearranging, solving problems by recalling the question and paying attention to the answer again.

Subject concluded that the answers before and after the check remained the same.

Talking about the difference, S1 was likely to disclose information known and asked using images and algebraic notation, while the S2 disclosed information known and questioned by the ratio formula without using image. Towards a problem-solving plan, S1 could determine the steps to resolve the problem with the two strategies or appropriate manner, while S2 might determine steps to resolve the problem only with the right strategy. In implementing the completion plan, S1 performed problem-solving activities as planned in advance by observing the items needed to solve the problem, while the S2 performed problem-solving activities as previously planned yet forgetting the important things needed in solving the problem.

Other findings obtained by researchers at the students' critical thinking process is the answer style process in the step of understanding problems, developing plans, doing completion, and rechecking the results. Visualizer subject tended to like to write doodles to analyze the answers. The verbalizer, however, tended to describe the analysis of the answer without writing it.

Based on the conducted analysis, it appears that the visualizer and verbalizer subjects' critical thinking process have differences in the process of understanding the problems, developing plans for REMEDY problems, carrying out problem solving plan, and rechecking the obtained results. In the ease of differences in understanding the issues, S1 may disclose information known and asked to use images and algebraic notation, while the S2 disclose information known and questioned by the ratio formula without image. In a troubleshooting plan, S1 was able to determine the steps to resolve the problem with the second strategy or appropriate way, while the S2 was able to determine the steps to resolve the problem only with the right strategy. In implementing the completion plan, S1 performed problem solving activities as planned in advance by observing the things needed to solve the problem, while the S2 performed problem solving activities as previously planned by forgetting the important things needed in solving the problem. In rechecking the results obtained, S1 checked each step by reading the problem again and recalculating the results of the answers. S2 checked each step by recalling and paying attention to the answers.

The other finding obtained by researchers towards the students' critical thinking process is the answer style process in the step of understanding problems, developing plans, implementing solutions, and checking the results. Visualizer subject tended to like to write doodles to analyze the answers. The verbalizer subject, however, tended to describe the analysis of the answer without writing it.

4. CONCLUSION

Based on the results and discussion, it can be concluded that the process of students' critical thinking in solving problems differs on all the steps that have been made. Of the student stylish cognitive visualizer: 1) the subject may disclose known and asked information to use images and algebraic notation in understanding the problem, 2) the subject can determine the steps to solve the problem with the two strategies or the proper way to prepare plans, 3) the subject performed problem solving activities as planned earlier by paying

attention to the things needed in solving the problems in implementing the plan of solving the problem, 4) subject re-examined the question by rereading and recalculating the results of the answers.

Shifting to the student with cognitive-style verbalizer: 1) the subject may disclose known and questioned information by using the ratio formula without image in understanding the problem, 2) the subject can determine the steps to solve the problem only with the right strategies in planning, 3) the subject of problem-solving activities as previously planned yet forgetting the important things needed in solving the problems in implementing problem solving plan, 4) the subject can do a recheck by recalling the questions and answers upon re-examining the results already obtained.

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