Factors of inhibit the mathematical critical thinking process of junior high school students

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Abstract. Students had difficulty in thinking critically mathematically. In faced of problems of simple shapes on plane geometry, students had difficulty in solving them. This is caused students had less able to think critically mathematically. Indicators of mathematical critical thinking in this study included clarification, assessment, inference, and strategies. First of all, a test was carried out on 25 students in one class, grade VIII MTsN 1 Temanggung. The average critical thinking ability is 62 (in interval 0-100). Furthermore, the research subject were selected 6 students representing the entire class, a more in-depth study was conducted through interviews. Based on the results of the thinking process in solving problems showed that students were low level in mathematical critical thinking due to: students feeling satisfied with the answered of problems; did not checking his/her work; did not accustomed to practice thinking deeply in solving problems; lacked of mastery of the concepts contained in the problems; and had difficulties in connecting between concepts.

1. Introduction
Based on the results of observations on the implementation of mathematics learning in junior high schools (SMP), for example in junior high schools in Semarang City, Semarang Regency; and Temanggung Regency, it is concluded that the questions given by teachers to those that did not emphasize improving critical-creative thinking ability in the realm of high level or higher order thinking (HOT). Mathematical problems given to students by the teacher tend to be at the level of remembering, understanding, and applying [1,2] which according to Bloom's Taxonomy is classified as lower order thinking (LOT). Another demand in the world of education is to provide learning that is innovative, interesting, and could be done anywhere and anytime. Blended learning is one of the learning innovations that can be done [3,4]. With the implementation of blended learning, it is hoped that it can minimize problems in conventional learning which are not able to facilitate various kinds of students characteristics such as initial ability, speed of mastering material, or learning styles of students [5,6].

Learning studies known as blended learning are blooming along with the times in the industrial 4.0 era. Castro [7, 8] stated that blended learning is closely related to technological innovation, institutional practices, interactions between institutions and the impact of technology policies. Manwaring [9] provided a definition of blended learning that focused on the percentage of time allocated for face-to-face arrangements with online learning activities: for example 50% online learning and 50% face-to-face or in some cases 30-79% online learning.
Furthermore, junior high school mathematics teachers used the old Bloom Taxonomy, did not the new (revised) Bloom Taxonomy. Based on the demands of the 2013-curriculum, junior high school students should have improved their critical and creative thinking skills so as to solve mathematics problems in the HOT-realm according to the Bloom's Taxonomy (which is new) at the analysing, evaluation, and creating levels. For this reason, it is necessary to explore students' critical-creative thinking ability [1, 7-10] in solving problems in the realm of HOT in blended learning.

2. Methods
This research was a research with a mix-method design. Tend to qualitative research. Quantitative data were processed using descriptive statistics, to support the exploration of students' mathematical critical thinking processes. The research design was described as followed. Problem formulation, theoretical basis, data collection, quantitative and qualitative data analysis, data analysis results, and drawing conclusions and suggestions.

Related to the critical thinking ability indicators refers to those proposed by Perkins and Murphy [11], namely clarification, assessment, inference, and strategies. The observed aspects of critical thinking include: (1) the ability to think in understanding and explaining problems (clarification); (2) ability to think in assessing problems (assessment); (3) the ability to make inferences in solving problems (inference); and (4) the ability to describe the possibilities and formulate a problem solving plan steps (strategies). To measured mathematical critical thinking ability, given test with 6 problems; two of them are related to plane geometry; one of the questions related to quadrilateral and the other related to triangles. In this research we try to explored the problems related to quadrilateral.

The research subjects consisted of one class; grade VIII MTsN 1 Temanggung, with 25 students. These 25 students were given a test with 6 problems to measured the students' ability in mathematical critical thinking. Furthermore, based on the test results, they were divided into three groups, namely the upper, middle, and lower groups of students. Upper group with an average score above 3; the middle group with an average score between 2 and 3; lower group with average score less than or equal to 2; with a discrete score range from 0 to 4. From each group we took 2 students were selected with certain considerations, for example having an android hand-phone and being able to communicate using WhatsApp; six selected students were interviewed in-depth covering one geometry problem in order to find out the mathematical critical thinking process in the plane geometry of the students in solving rectangular mathematical problems. As well as data triangulation; comparing the results of written tests and interviews; from written test results data to predict students' thinking and how the development of students' critical thinking processes in solving mathematical problems. And it is clarified by improving student worked in solving problems during the interview. Even though WhatsApp group was formed; but interviews were carried out personally via WhatsApp with sufficient time duration for students to think deeply. The WhatsApp group is used for general information and is not focused on exploring students' abilities.

3. Results and Discussion
The research was carried out during the Covid-19 pandemic, can took place smoothly in data collection. Learning was done by using Blended Learning [6,7], initially in the first two months, face-to-face learning is carried out using the discovery learning model. Furthermore, learning was carried out online using WhatsApp assistance and learning management system learning applications available at MTsN 1 Temanggung. As instrument the test had been validated by experts in the field of mathematics education and were tested face-to-face in classroom on 25 students. The test scores are presented in Table 1 below.
Table 1. Scores of students mathematics critical thinking ability

| Name  | K1 | K2 | K3 | K4 | K  | Name  | K1 | K2 | K3 | K4 | K  |
|-------|----|----|----|----|----|-------|----|----|----|----|----|
| Std 1 | 3  | 3  | 3  | 2  | 2.75| Std 14| 2  | 2  | 2  | 1  | 1.75|
| Std 2 | 3  | 3  | 3  | 2  | 2.75| Std 15| 2  | 2  | 2  | 1  | 1.75|
| Std 3 | 3  | 3  | 3  | 2  | 2.75| Std 16| 3  | 3  | 2  | 2  | 2.5 |
| Std 4 | 4  | 4  | 4  | 3  | 3.75| Std 17| 4  | 3  | 3  | 2  | 3  |
| Std 5 | 3  | 3  | 3  | 2  | 2.75| Std 18| 2  | 2  | 2  | 1  | 1.75|
| Std 6 | 3  | 3  | 3  | 3  | 3  | Std 19| 2  | 2  | 2  | 1  | 1.75|
| Std 7 | 3  | 3  | 3  | 3  | 3  | Std 20| 2  | 2  | 2  | 1  | 1.75|
| Std 8 | 3  | 2  | 2  | 2  | 2.25| Std 21| 3  | 3  | 2  | 2  | 2.5 |
| Std 9 | 4  | 4  | 3  | 2  | 3.25| Std 22| 4  | 3  | 3  | 2  | 3  |
| Std 10| 3  | 2  | 2  | 1  | 2  | Std 23| 3  | 3  | 2  | 2  | 2.5 |
| Std 11| 3  | 2  | 2  | 1  | 2  | Std 24| 4  | 3  | 3  | 2  | 3  |
| Std 12| 3  | 2  | 2  | 1  | 2  | Std 25| 3  | 3  | 3  | 2  | 2.75|
| Std 13| 2  | 2  | 2  | 1  | 1.75|       |     |     |     |     |     |

Average 2.48

Notes: Indicators of mathematics critical thinking: K1 Clarification, K2 Assessment, K3 Inference, K4 Strategies, and K. Average.

Assessment using a scoring rubric with a discrete scale of 0 to 4. The results of the test were as in Table 1. In general, the average score is 2.48 on a discrete scale of 0 to 4; and if converted into a rating scale of 0 to 100 the average was 62; and this is in the adequate category.

If students' mathematical critical thinking ability are presented in the histogram graph as follows. As shown in Figure 1.

![Histogram of students' mathematical critical thinking ability](image)

Figure 1. Histogram of students' mathematical critical thinking ability

Based on the students' abilities as shown in Figure 1. The six research subjects were selected to determine the plane geometry critical thinking ability to be interviewed. Namely students with abilities in the upper group Std 4 and Std 9; middle group Std 22 and Std 24; and low groups Std 10 and Std 14. To determined critical thinking ability in plane geometry. The interview focused on the problem of test number 6 as follows.

Draw properly and follow the conditions as follows. (Picture can be more than 1).

a) A parallelogram with sides 14 cm and 16 cm; height 14 cm.
Also calculate the area!

b) A parallelogram with sides 17 cm and 29 cm; height 19 cm.
Also calculate the area!

Examples of student worked in the low category was shown in Figure 2 as follows.
Figure 2. Worked of Std 14

Based on the student worked in Figure 2, low group students tend to be weak in all aspects of the indicators of critical thinking. It tends to be more difficult to improved their mathematical critical thinking ability, as according to [12], even though they had high enthusiasm. For example, excerpt from interviewed with Std 14. (R = researcher; S = Student).

R: Study number 6 first. The worked is still wrong, the picture did not quite right.
Try to draw it again, either 6a or 6b.
S: Yes, sir. I am ready.
R: To be able to draw well (and also do well) for number 6, you need to understand very well about the characteristics of a parallelogram. What is a parallelogram?

Although the student given enough time, there was no more response from Std 14. This indicated the weakness of Std 14 in understood the concepts of simple quadrilateral shapes. Students did not master the concept of levels and characteristics of parallelogram. In addition, based on Figure 2, from the observations on the line sketch, the analysis and calculation algorithms of students shown the inability of Std 14 to solve the problem at hand, as according to [13].

Middle category students, Std 24 in done the problem as follows.

Figure 3. Worked of Std 24

Based on the student worked in Figure 3, students in the middle group tend to be less careful in thinking; students did not understand what the parallelogram and then they made mistake in sketching the pictures, as according to [1, 4, 10]. Std 24 did not know that square is parallelogram. Students tend to be able to improved their mathematical critical thinking ability. As an example of an interview excerpt with Std 24 as follows.

R: Learn from number 6 first. First, all of you have to know the characteristics of a parallelogram. Try to remember what the main features of a parallelogram are.
S: Characteristics of a parallelogram shape; 1. to have two sides of the same length; 2. has two pairs of parallel sides; 3. the sum of the four angles is 360 °; 4. has two pairs of equal angles 5. has two diagonals of the same length; and 6. has two rotational symmetries.
R: Oow yes, the most important thing is called a parallelogram if the quadrilateral and its sides are parallel (or a parallelogram is a quadrilateral whose sides are the same length).

After understanding what a parallelogram is. Now try again on number 6. Either 6a or 6b. The pictures /sketches no. 6a and 6b are still incorrectly trying to be corrected.

S: (answer S, draw as in Figure 4 (Picture 4))

Figure 4. Revised of worked of Std 24

R: That's 6a, and 6b, both pictures were still wrong. The critical reason, for example, is that the hypotenuse and the vertical side cannot be the same length. Of course it should be the slanted length. Think it again, and then draw it again.

S: With regard to the length of sides 14 and 16 sir, I am ... really confused.

R: Try now to make a rectangle with sides measuring 16 cm and 14 cm. Try to draw it hopefully.

S: (Can make a rectangular picture with sizes 16 and 14). Sir give me, the answers, please!

R: Rectangle that you made, a parallelogram or not?

S: No sir.

R: False: a parallelogram. The rectangle is also a parallelogram. Why? Because AB = DC and AD = BC. (That's the mathematical way of thinking, "all rectangles, are parallelograms). Observed by its nature (definition)." parallelograms are rectangles whose sides (opposite sides) are the same length.

S: Yes Sir, thanks for these knowledge.

Examples of student worked in the upper class category; here is the worked of Std 17.

Figure 5. Worked of Std 17

Based on the student worked in Figure 5, the upper group students; students was fluent in understanding the parallelogram and could find their area correctly. But did not flexible in thinking yet, as accroding to [7, 13]. The interview excerpt with Std 17 indicates his/her ability could be upgraded to higher, as according [14, 6-15].

R: Yes, the picture already shows a parallelogram image. The 6a picture is correct but just found one.

S: (Sketching figure 6)
Figure 6. Worked of Std 17 find another solution

R: The 6a picture is still wrong. Guide question: is a rectangle including a parallelogram or not?
S: (Sketching figure 7)

Figure 7. Worked of Std 17 found another solution

R: Right anwer. So 6a there are two ways to answers. And you have found the answers.

4. Conclusion
Students with lower abilities in solving of mathematical problems difficult to improved their critical thinking ability. Lower ability students tend to be lazy to checked their answers again, did not want to think deeply about their work, mastery of material concepts that were less stable; and made difficulties in linking some concepts. Students with middle ability could improved their critical thinking ability by doing a lot of instructions through question-and-answer interactive communication, and was took rather a long time; and students with upper abilities tend to be easy to improved their mathematical critical thinking ability and more faster used it in solving problems.

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