Analysis of students’ critical thinking in solving geometry problem based on learning archivement

W S R Y Sultra*, B Usodo and I Pramudy
Postgraduate of Mathematics Education, Sebelas Maret University, Jl. Ir. Sutami No.36A Surakarta 57126, Indonesia

*Corresponding author: wseptirahma@gmail.com

Abstract. Critical thinking ability is important for students in learning because it will help when the process of understanding, analyzing and solving problems. The purpose of this study to find out how critical thinking ability of student in solving geometry problems with high, medium, and low learning achievement. The critical thinking ability of this study consists of 5 indicators, namely (1) giving a simple explanation; (2) provide reasons for a decision; (3) conclude; (4) provide further explanation; (5) set the right strategy to solve the problem. Critical thinking ability test is given to 30 eighth grade students of SMP Negeri 2 Masaran. The method used is descriptive qualitative research with 3 samples using by purposive sampling technique. The results show that students with high learning achievement can conclude and organize good strategies to solve problems. Students with medium learning achievement are completing steps that have not been optimal so that they have not achieved all the indicators of critical thinking. Students who have low learning achievement have difficulty in giving simple explanations in the early stages so they can’t solve problems and not find the right answers.

1. Introduction
Mathematics is an important lesson because it has many uses to develop science and technology. However, many view that mathematics is a difficult lesson. One of the factors that cause to the emergence of this view was that mathematics learning in schools did not construct students’ thinking abilities. Learning environments should be constructed, one of which is by trying to develop thinking abilities [1]. Practice of students' thinking ability is important so that students not only memorize the material given by the teacher but also develop their knowledge. Based of Permendiknas No. 23 of 2006 also explained that mathematics subjects need to be given to all students at every level of education including junior high school as a basis for developing the ability to think logically, analytically, systematically, critically, creatively, and collaboratively in students [2]. Therefore, it is required to analyze students' thinking ability, one of them is the critical thinking ability in solving mathematical problems.

Mathematics learning fosters critical thinking and problem solving [3]. The ability of students to communicate with solving mathematical problems needs to be developed in view of the increasing claims of the times such as the achievement of the extent of students' critical thinking abilities. However, efforts to train students 'critical thinking ability are less applied to learning that causes students’ abilities to be low. Mathematics learning in schools is generally still teacher-centered and tends to be rote so that students' critical thinking ability are still below average and very difficult to develop. Students not only have to use critical thinking ability in class, but also can activate it in real
life and to recognize situations when these abilities must be used [4]. Student learning context is one of the factors that contribute to the lack of generic ability, especially towards the critical thinking ability and solve problems, for example of the learning process in a classroom that emphasizes learning by memorization and focusing on content causes students to memorize the knowledge learned, not to analyze and synthesize the true meaning of knowledge [5].

The critical thinking ability can help students understand, analyze, and solve problems. Critical thinking gives students the opportunity to share ideas, strategies, and ways of working how to solve a problem [6]. Critical thinking explains what is thought by learning how to ask, when to ask, what questions, what reason, when to use reasoning, and what reasoning method to use [7]. Then Ennis (1996) states that critical thinking is rational and reflective thinking aimed at deciding what to believe or what to do [8]. There are five indicators of critical thinking derived from critical activities based of Ennis (1996), namely (1) giving a simple explanation; (2) provide reasons for a decision; (3) conclude; (4) provide further explanation; (5) set the right strategy to solve the problem [9]. Therefore, the critical thinking ability can encourage students to analyze a problem with their own thoughts and confirm that students have determined the solution.

In school learning, the teacher can practice critical thinking ability by giving students challenging mathematical problems such as geometry. Elements of critical thinking and mathematical ability to analyze began to come in the form of geometric concepts as they began to develop early [10]. Schools must provide a learning environment that helps every child at every school level to develop critical thinking ability, because these abilities do not develop naturally [11]. An effort is needed to encourage students to analyze a mathematical problem with their own thoughts so that the purpose of this writing is to find out how far the critical thinking skills of middle school students in solving geometry problems. From the process of analyzing and determining solutions, students can get conclusions optimally.

2. Methods
This study uses descriptive qualitative research methods. The study was conducted on class VII subjects of SMP Negeri 2 Masaran and 3 students were selected by using purposive sampling technique. The selection of research subjects is based on (1) each student is chosen with high achievement, medium achievement and low achievement (2) students have received the material to be studied; (3) students have taken a critical thinking ability test. Student learning achievement is seen from the results of the final exam in class VII. Data collection techniques use critical thinking ability tests and interviews. Data validity using technical triangulation means researchers use different data collection techniques to obtain data from the same source, namely comparing the results of critical thinking ability test and interviews. The critical thinking ability test instrument was developed based on indicators of critical thinking according to Ennis (1996), namely (1) giving a simple explanation; (2) provide reasons for a decision; (3) conclude; (4) provide further explanation; (5) set the right strategy to solve the problem. Then the results of the analysis are obtained from students' answers to the achievement of each indicator of critical thinking ability.

3. Result and Discussion
3.1. Indicator of Critical Thinking Ability
Analysis of student test results is obtained based on indicators of critical thinking skills. The following is an indicator of critical thinking ability developed by Ennis (1996).

| No | Indicator                              | Description                                      |
|----|----------------------------------------|--------------------------------------------------|
| 1  | Giving a simple explanation            | Find facts, data, or information known.           |
|    |                                        | Link how each information is related.             |
| 2  | Provide reasons for a decision         | Consider whether the source can be trusted or not. |
Mention the questions raised in the problem.

3 Conclude
Determine the results of consideration to solve the problem.
Find steps to solve problems.

4 Provide further explanation
Identify information.
Use relevant information on problems or prior knowledge to solve problems.

5 Set the right strategy to solve the problem
Explain well the steps to solve the problems that have been found.
Attract the right conclusions from the answers obtained.

The test questions used is "A square shaped pool measuring 6,400 cm². On the outside of the pool will be made a fence that surrounds the pond. The distance between the fence and the pond on each side is 10 cm. Calculate circumference the pool and circumference the fence."

Table 2. Guidelines for Analysis of Indicators on Critical Thinking Ability Problems

| No | Indicator                                      | Description                                                                 |
|----|-----------------------------------------------|-----------------------------------------------------------------------------|
| 1  | Giving a simple explanation                   | Write down information and what is known (area and distance of the fence with ponds on each side) |
| 2  | Provide reasons for a decision                | Write down the questions in the problem (circumference the pool and circumference the fence) |
| 3  | Conclude                                      | Find steps to solve problems (determine and calculate how long the side of the pool) |
| 4  | Provide further explanation                   | Use relevant information in the problem or prior knowledge to solve the problem (calculate how long the side of the fence) |
| 5  | Set the right strategy to solve the problem   | Explain well the steps to solve problems that have been found (determine the circumference of the fence and circumference of the pool and find a complete and precise conclusion) |

3.2. Result
From the result of the final semester grades in class VII, 3 students were chosen with high achievement, medium achievement and low achievement.

Figure 1. Subject 1 answers with high learning achievement
Based on the answers of students, subject 1 solved the problem by first writing down what is known, namely the area of the square and the distance of the side of the pool with the fence. Subject 1 uses steps to solve the problem by finding the length of the side of the fence and the length of the side of the pool. Students use information obtained previously to get circumference the pool and circumference the fence. Next the students concluded circumference the 320 cm pool and circumference the 400 cm fence. This is in accordance with subject statement 1 "From what is known, each fence and pool distance is 10 cm so that the side of the fence can be calculated. Then after obtaining the length of the side of the pool and fence, the circumference is calculated by adding up each square-shaped side. Subject 1 can solve the problem through good steps and can make conclusions. Therefore, subject 1 can complete up to arranging the right strategy to solve the problem.

In figure 2, the answer to subject 2 with medium achievement. It can be seen that subject 2 has answered until it gets an answer, but in conclusion the subject 2 writes the pool = 320 cm + 400 cm = 620. The final step is not right because the question only reaches the circumference, not looking for the number circumference the pool and circumference the fence. Based on the interview the students said "I think that was asked about the question was that the all circumference, so I added it". Subject 2 did not understand and interpret was asked about the question. So, subject 2 has not reached the indicator set the right strategy to solve the problem.

In figure 3, the answer to the subject 3. The initial step when looking for the pool side, subject 3 error determines √6400. "It is known that the area of the pool is 6400 cm² square and the circumference is asked". Then when asked how to do the students said "I am confused about how to calculate the side of the pond, counting what the root looks like?". This makes subject 3 unable to get problem solving. Subject 3 is unable to find the right step and uses information or prior knowledge to solve the problem. Students have difficulties when considering steps to solve problems.
3.3. Discussion

Based on the results of the analysis test and student interviews, it can be seen that students with better achievement critical thinking ability compared to students whose achievements are not good. A student can be said critical thinking if the student is able to test his experience, evaluate knowledge, ideas, and consider arguments before getting conclusions [7]. Critical thinking ability is an effective way to improve students' understanding of mathematical concepts because it helps in interpreting, analyzing, and evaluating [12]. The critical thinking ability requires a series of information and result processes or standards based on the thoughts possessed [13]. So that students can use these abilities and standards to control their behavior. On the other hand, students still find it difficult to solve problems related to geometrical material. Material about geometry, most of the competencies obtained by students are still considered to have difficulties [14]. Therefore, developing critical thinking in students helps improve student learning achievement in the classroom [15]. The critical thinking requires extensive information with the ability to find, organize, and evaluate information [16].

Critical thinking ability helps students in understanding and solving mathematical problems to obtain relevant knowledge. To find out students' critical thinking ability is inseparable from how students solve problems that require understanding and problem solving. A good mathematical performance from students can develop the level of critical thinking skills and their ability to solve problems [14]. Critical thinking that is often associated with problem solving requires analysis, evaluation, and justifying the decisions chosen [17]. Using critical thinking and problem solving, students can form various unique ways to solve problems [18]. In addition, the critical thinking ability includes in the high-level thinking skills or Higher Order Thinking Skills (HOTS). The critical thinking ability requires more than just high-level thinking skills that are focused on logical decision making, obtaining and assessing information [19]. By emphasizing the critical thinking ability in a continuous curriculum, our students will not only maintain, but also improve their learning achievement because students will be embedded in future behavior [20]. Effective mathematics teaching involves mathematical pedagogical knowledge, application of knowledge in mathematical content, and students' mathematical thinking ability [21].

4. Conclusions

The results of the analysis show that students with high learning achievement can conclude and organize good strategies to solve problems. Students with learning achievement are completing steps that have not been optimal so that they have not achieved all the indicators of critical thinking. Students who have low learning achievement have difficulty in giving simple explanations in the early stages so they cannot solve problems and cannot find the right answers. Efforts must be made to develop critical thinking skills in order to obtain improved academic achievement in mathematics.

Acknowledgments

I would like to thank the research subjects and Negeri 2 Masaran junior high school for being willing to help with the process make of this paper.

References

[1] Aktas G S and Unlu M 2013 Procedia - Soc. Behav. Sci. 93 1
[2] Kemendiknas 2006 Permendiknas No 22 Tahun 2006 tentang Standar Isi untuk Satuan Pendidikan dan Menengah SMP/MTs (Jakarta: Kementrian Pendidikan Nasional)
[3] Brandi N H, Morgan Z F and Mei-Lin C J. Multicult. Educ. 10 3
[4] Aizikovitsh E and Amit M 2010 Procedia - Soc. Behav. Sci 2 1
[5] Rodzalan S and Saat M 2015 Procedia - Soc. Behav. Sci. 172 1
[6] Sanders S 2016 J. Stud. Engagem.: Educ. Matters 6 1
[7] Fisher A 2008 Berpikir Kritis-Sebuah Pengantar (Jakarta: Erlangga)
[8] Rosnawati R, Kartowagiran B and Jailani 2015 Res. Evaluation in Educ. J. 1 2
[9] Nio T H, Sikestitiyano Y L, Waluya B, Rochmad, Isnarto and Manullang B 2017 Int. J. Contemp. Appl. Sci. 4 1
[10] Dinuta N 2015 Procedia - Soc. Behav. Sci. 180 1
[11] Fonseca L and Arezes S 2017 J. Eur. Teach. Educ. Netw. 1 2
[12] Chukwuyenum A N 2013 J. Res. Method Educ. 3 5
[13] Beckmann J and Weber P 2016 Interact. Technol. Smart Educ. 13 1
[14] Alcantara E and Bacsa J 2017 Asia Pac. J. Multidiscip. Res. 5 4
[15] Bahmani S 2016 Int. J. Social. Soc. Policy 36 3
[16] Jacalyn E B and 2014 Ref. Serv. Rev 42 3
[17] Carla L W 2017 Educ. Train. 59 1
[18] Bradshaw Z and Hazell A 2017 Int. J. Lesson Learn. Stud. 6 1
[19] Ulger K 2016 J. Educ. 31 4
[20] Michèle S and Dorothy S 2014 J. Commun. Manag. 18 3
[21] Helen F and Jill C 2015 Incl. Pedagogy Across Curric. 7 1