The improvement of students’ mathematics critical thinking abilities in topic prism and pyramid by using the Problem Posing approach

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Abstract. This study aims to determine the increase in mathematical critical thinking skills in high school junior students by applying the Problem Posing approach. One hundred ninety-two students were sampled, divided into six classes. Samples from the study were two classes (one as the experiment and the other as the control class). The results of this study indicate that 1) based on the average post-test score, the experimental class is better than the control class; 2) based on the results of N-Gain, the experimental class is better than the control class, even though both are in the medium category; and 3) based on the right-hand t-test, it is proven that the mathematical critical thinking ability of the experimental class is better than the control class. So, it can be concluded that Problem Posing learning in students can improve mathematics critical thinking skills.

1. Introduction
Critical thinking is a process of using rational and reflective thinking abilities that aim to make decisions about what is believed or done [1]. Meanwhile, according to Paul and Elder in Jacob [2] critical thinking is a process in which thinkers improve the quality of thinking by skillfully taking over structures inherent in thought and imposing intellectual standards. The ability to think critically in learning mathematics can be developed by exposing students to new and contradictory problems so that they construct their minds to search for truth and clear reasons. The elements that include critical thinking in mathematics are thinking that tests, questions, connects, evaluates every aspect that exists in a particular problem or situation [3].

Critical thinking skills are an effective way to enhance students’ understanding of mathematical concepts because skills have helped in interpreting, analyzing, evaluating, and presenting thinking logically and sequentially [4]. Thus, the ability to think critically mathematically is the ability that should be possessed by every student to solve mathematical problems, including students. But the reality that occurs in the field is just the opposite. The learning process used is conventional learning. The teacher explains the material through the lecture method, where the teaching is teacher-centered. Students receive the material by listening to what is taught. Students record what the teacher records on the blackboard, and even some students do not take notes. So students only receive information from the teacher and tend to be passive in learning, which causes the ability of students to think critically, not appear. As stated by Slameto [5] “Teachers usually teach using the lecture method only so that students...
become bored, sleepy, passive and take notes.” Thus, it is needed an effort to improve students’ mathematical critical thinking skills so that students’ learning achievement increases.

Problem Posing learning approaches can improve students’ critical thinking skills [6][7][8]. Posing Problem posing is seen as an approach that can motivate students to think critically and be able to enrich learning experiences, thus ultimately improve students’ learning outcomes [9]. Problem Posing contains activities composing new problems or formulating the original Problem based on a series of data or information presented [10]. Silver [11] classifies Problem Posing into three types. Its types are based on different forms of cognitive activity. Pre-solution Posing type is students make questions from the situation being held. Within-solution posing type is students reformulate the questions they have been completed. Post-solution posing type is students modify the objectives of the condition of the questions that have been completed to create new problems. Learning using Problem Posing stimulates students to develop three aspects of critical thinking skills identifying assumptions, answering accompanied by reasons, checking the truth of arguments, statements of the solution process.

This study was conducted to answer the following questions: 1) How the students’ mathematics critical thinking abilities are achieved after the implementation of Problem Posing approach in topic prism and pyramid?, 2) How is the application of the Problem Posing approach to students’ critical thinking?, and 3) Is the ability to think critically mathematically students who get the Problem Posing approach better than the ability to think mathematically critical students who get a conventional approach in topica prism and pyramid?.

2. Methods
This research utilized quasi-experimental research. The sample was selected from existing groups, or known as intact groups [12]. Sampling in this design using intact groups. The number of subjects in the experimental group and the control group respectively differ. Design with an Unequal Control Group begins by selecting two intact groups, one group being the experimental group that will receive the Problem Posing Approach, and one group being the control group that will achieve the Conventional Approach. Furthermore, before the implementation of the treatment, a pre-test was conducted. Then, the experimental group was given the Problem Posing Approach, while the control group remained with the Conventional Approach. After the treatment, both groups were given a post-test.

The population of this study is 192 junior high school students, consisting of six. Samples were selected randomly, and class B (24 students) was assigned as the experimental class and class C (23 students) as the control class. A one-party t-test was used to examine whether students’ mathematical critical thinking skills are improved after learning Problem Posing as compared to conventional learning. One party’s t-test used was a right-hand party.

3. Result and discussion
The results of the study in the form of pre-test and post-test scores were calculated using the average of each class based on the overall factors of students’ initial mathematical abilities. Then, each n-gain of the test score is also performed to identify the changes in mathematics critical thinking skills based on the overall factors of students and KAM. The grouping of students’ initial mathematical ability (KAM) based on the test scores obtained. KAM is high if the score is 80-100, moderate if the score is 60-79, and low if the score is 0-59. The completeness in each class is seen from the average post-test scores. The average post-test is seen in figure 1.
Figure 1. Average post-test score.

The high KAM group in the experimental class, the average post-test score was completely reached minimum completeness criteria (KKM). The minimum completeness criteria (KKM) for learning mathematics is 75. Figure 1 showed that the average experimental class was much better than the control class. This shows that the application of the Problem Posing approach will be more leverage if applied to students with high KAM. Furthermore, from figure 1, it is also seen that the average post-test of the experimental class is always better than the control class based on the overall factors of students and KAM. It proves that the mathematical critical thinking ability of the experimental class students is better than the control class. Also, It can be seen from the percentage of students who completed the Weiner Table that is presented in figure 2.

Figure 2. Percentage of students who complete.

From figure 2, it can be seen that the percentage of students who completed the experimental class was higher than the control class based on the overall factors of the students and KAM. In the experimental class, the highest percentage of students who completed reached 67 percent, namely in the high KAM group. In contrast, the lowest percentage occurred in the low KAM group, which was only 38 percent. Whereas in the control class, the highest percentage of students who completed only reached 40 percent, namely in the high KAM group. In comparison, in the low KAM group, the percentage was 0 percent meaning that in the low KAM group, all students did not complete the KKM. If seen based on the overall factors of students, the percentage of students who completed the experimental class was also greater than the control class, where the percentages are 50% and 13%, respectively. It also shows that the mathematical critical thinking ability of the experimental class students is better than that of the control class.

The evidence that the mathematical critical thinking ability of the experimental class students was better than the control class was also statistically proven by the right-side t-test. Before conducting the right-side t-test, a prerequisite test is conducted, namely the normality test and homogeneity test, to determine the formula used in the right-side t-test. From the results of the t-test, the right side shows that H₀ is rejected. The conclusion is the mathematical critical thinking ability of the experimental class is better than the control class. So, it can be concluded that the ability to think critically mathematically students who get the Problem Posing approach is better than the ability to think mathematically critical students who get a conventional approach. It happens because the Problem Posing learning applied in the experimental class, stimulated the students to develop three aspects of critical thinking skills.
Students are encouraged to identifying assumptions, answer with reasons, checking the truth of arguments, statements of the solution process both when posting questions or giving answers. Meanwhile, the control class did not apply Problem Posing learning. The learning process used is conventional learning, the teacher explains the material through the lecture method where the teaching is teacher-centred.

In the Weiner Table can also be seen as an increase in mathematical critical thinking skills by looking at the N-Gain. However, the N-Gain presented in the Weiner Table is only N-Gain as a whole; the ability to think critically mathematically, not per aspect. Actually, in this study, N-Gain calculations were also done per an aspect of mathematical critical thinking abilities. The results of N-Gain calculations each aspect of mathematical critical thinking ability of the experimental class are presented in figure 3.

![Figure 3. Improvement per an aspect of mathematics critical thinking ability class experiment.](image)

From figure 3, it can be seen that in the experimental class, all aspects of mathematical critical thinking skills increase based on the overall factors of students and KAM. On the overall factor of students, the highest increase occurred in the aspect of identifying assumptions with N-Gain 0.78. In contrast, the lowest increase occurred in the aspect of checking the truth of the argument with N-Gain 0.28. And in the KAM factor, the highest growth occurred in the high KAM group in the aspect of identifying assumptions with N-Gain 0.86. While the lowest increase occurred in the low KAM group in the answering aspect with reasons of N-Gain 0.21, but in the aspect of identifying assumptions between the moderate and low KAM groups, the N-Gain was higher in the lower KAM group. Meanwhile, the results of the N-Gain each aspect of the mathematical critical thinking ability of the control class are presented in figure 4.

![Figure 4. Improvement per an aspect of mathematics critical thinking ability class control.](image)
Figure 4 shows that in the control class, all aspects of mathematical critical thinking skills increase based on the overall factors of students and KAM. On the overall factor, the highest enhancement occurred in the aspect of identifying assumptions with 0.80 N-Gain scores. In contrast, the lowest increase occurred in the aspect of checking the truth of the argument 0.18 N-Gain score. The highest increase occurred in the KAM group while in the aspect of identifying assumptions with N-Gain 0.89.

The most insufficient enhancement happened in the KAM group. While checking aspects of the truth of the argument is 0.13 N-Gain. So, from figure 3 and figure 4, it can be concluded that there is an increase in all aspects of mathematical critical thinking skills in the experimental class and the control class based on the overall factors of students and KAM. Furthermore, for overall improvement in mathematical critical thinking skills can be seen from the N-Gain presented in the Weiner Table.

Based on the N-Gain (g) in the Weiner Table for the experimental class showed an increase in the moderate category based on the overall factors of students and KAM. Meanwhile, the control class in the low KAM group showed an increase in the low category and the other KAM group and based on overall factors, and the students showed an increase in the moderate category. This indicates that in the experimental class and the control class, there is an overall improvement in mathematical critical thinking skills. However, if the experimental class g is compared to the control class, then the experimental class g is higher than the control class. This means that the increased mathematical critical thinking ability of the experimental class is higher than the control class. From the discussion of the above research results, it can be concluded that the learning of Problem Posing in students on algebraic operating material can improve all aspects of mathematical critical thinking ability based on overall factors and KAM.

Problem Posing learning can also improve other high-order thinking skills besides critical thinking [13]. Students with Problem posing did not find constructing problems difficult and complicated [14]. Kelen [15], in his research, results that Problem Posing learning can improve students’ creative thinking skills. Learning Problem Posing is very appropriate to be applied to mathematics [16]. The results of this study are also in line with Suryoboroto [9] assessment, which revealed that the Problem Posing approach motivates students to think critically as well as be dialogical, creative, and interactive.

4. Conclusions
First, the achievement of students’ critical thinking skills with Problem Posing based on the overall student factor has not been completed. But based on the high initial mathematical ability (KAM) group in the class that received complete treatment, while the conventional class was not complete. This can be seen from the average post-test score based on the overall student. Second, there is a significant change in students’ critical thinking skills after receiving the Problem Posing approach. The results of the N-Gain test experienced a moderate increase in category. Third, based on the statistical analysis (right side t-test), it shows that the class mathematical critical thinking ability with Problem Posing is better than the conventional class in topic prism and pyramid.

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