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Ethnomathematics-Problem Posing Improves Mathematical Critical Thinking Ability of Elementary School Students

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Abstract

Ethno-problem posing is a learning approach that emphasizes an in-depth understanding of culture and issues related to a particular community and invites students to think critically and find solutions to existing problems. The research used a quasi-experimental method in elementary schools in Ambon City. This study aims to determine the difference in improving mathematical critical thinking skills of students whose learning uses the ethno-problem possing approach and those who learn conventionally. The study population was all fifth-grade students of elementary schools in Ambon City, and the sample was taken randomly from as many as six public elementary schools in Ambon City. The instrument used in the study was a test instrument. Two tests were used, namely the initial test and the final test. The data analysis technique used Normalised Gain to see an increase in students' mathematical critical thinking ability based on school level with high, medium, and low categories. The results showed that students' mathematical critical thinking ability using an ethno-problem possing approach is better than conventional learning. Thus, the ethno-problem possing approach in learning mathematics has the potential to be applied in learning to improve the quality of education through good critical thinking skills and is expected to motivate students to learn better mathematics.

Keywords: *Problem Posing, Ethnomathematics, Critical Thinking.*

Introduction

Maths is an essential part of the curriculum in primary school (Aledya, 2019; Muizlidinillah, 2011) and aims to develop students' mathematical concept understanding and critical thinking skills. (Apino & Retnawati, 2017; Firdaus et al., 2015). However, students often find it challenging to relate mathematics to their daily lives. (Albert & Antos, 2000; Rajkumar & Hema, 2017; Yavuz Mumcu, 2018), Thus affecting students' motivation and interest in mathematics (Albert & Antos, 2000; Yavuz Mumcu, 2018). One approach that can be used to improve

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students' understanding and interest in mathematics is the ethnomathematics approach; this aligns with several studies that mention that Ethnomathematics and culturally relevant pedagogy can increase students' motivation in mathematics. (Staats, 2006), ethnomathematics-based teacher education courses can increase student motivation and engagement in mathematics learning (Verner et al., 2013). the importance of integrating cultural elements and folklore, as well as values from students' daily lives and communities, into the mathematics curriculum to improve students' motivation and academic performance (Fouze & Amit, 2018), integration of ethnomathematics folklore games in mathematics learning to develop students' mathematical thinking and conceptions, increase motivation, and maintain an engaging learning process (Rosa & Orey, 2011), students taught using the ethnomathematics approach scored significantly higher than students taught using the traditional lecture approach. Teachers appreciated the ethnomathematics approach as students were motivated and interested in learning. (Sunzuma et al., 2021).

Ethnomathematics is an approach to learning mathematics that integrates culture, tradition, and social context in the teaching and learning of mathematics (D'Ambrosio & Rosa, 2017; Orey & Rosa, 2007; Rosa & Gavarrete, 2017; Rosa & Orey, 2016). In the context of improving the mathematical critical thinking skills of primary school students, Ethnomathematics can be used as an effective strategy. Several studies have shown that there is a relationship between Ethnomathematics and critical thinking skills of primary school students, including ethnomathematics tasks in the context of Yogyakarta have the potential to improve student's critical thinking skills (Richardo et al., 2019); students' logical thinking skills can be measured using ethnomathematics-based mathematical literacy (Julianto et al., 2021), incorporating Ethnomathematics into the mainstream mathematics curriculum can foster meaningful connections and addresses vital principles of a critical ethnomathematics curriculum (Naresh, 2015), contextual learning with Ethnomathematics improves problem-solving ability based on thinking level (Nur et al., 2020), Ethnomathematics can make school mathematics more relevant and meaningful to students, thereby improving the overall quality of education. (Rosa & Orey, 2011), Android-based AR learning media with an ethnomathematics context effectively improves students' creative thinking skills. (Richardo et al., 2023).

Critical thinking skills are essential for primary school students as they provide a strong foundation for intellectual development and future success (AlJaafil & Sahin, 2019; Firdaus et al., 2015; Gelerstein et al., 2018). The importance of critical thinking skills for primary school students includes: Critical thinking skills enable students to analyse problems, evaluate options, and develop practical solutions (Kronberg & Griffin, 2000; Pogonowski, 1987), Critical thinking helps students make informed decisions by considering multiple points of view, gathering information, and evaluating alternatives (Gambrill, 2005), developing critical thinking skills empowers students to think independently and form their own opinions (Aizikovitsh-Udi & Cheng, 2015; Kennedy, 2007; Kivunja, 2014), critical thinking improves students' ability to think logically and make logical connections between ideas (Aizikovitsh-Udi & Cheng, 2015; Splitter, 1991), Critical thinking promotes creativity by encouraging students to think at a higher

level in exploring new points of view, and generating innovative ideas (C.Anusuya(a)Priya, 2012; Splitter, 1991), critical thinking skills support effective communication by helping students organise their thoughts, articulate their ideas clearly, and convey them coherently (Vong & Kaewurai, 2017).

Critical thinking skills are closely related to Problem Posing; this is known from several studies, including Problem-based learning is an effective way to develop critical thinking skills in higher education is one of the methods that can develop critical thinking skills (Kowalczyk, 2011; Morales Bueno, 2018); problem-based learning and mathematical Problem posing are more effective than conventional learning in improving critical thinking skills in university students (Darhim et al., 2020), Problem posing learning is better than direct learning in improving critical thinking and mathematical communication skills in elementary school students (Juano & Pardjono, 2016) critical thinking helps in analyzing, evaluating, and interpreting information (Chukwuyenum, 2013; Din, 2020; Rüütmann, 2019), while Problem posing involves the ability to ask challenging questions (Gonzales, 1998; Van Harpen & Sriraman, 2013). Combining these two abilities allows one to identify problems better, question underlying assumptions, and develop innovative problem-solving.

Problem-posing is a learning approach that allows students to ask questions, solve problems, and develop their understanding (Lee, 2005; Silver, 1994). The concept was first introduced by George Pólya in 1945 and has become a significant focus in mathematics education (Abu-Elwan, 2002; Lewis et al., 1998; Voskoglou, 2011). In this context, Problem posing can be applied to various subjects and levels of education. The application of Problem posing in learning has several significant benefits. Firstly, Problem posing can increase students' engagement in learning, as they actively ask questions and find solutions (Mayer & Wittrock, 1996). Secondly, Problem posing can develop students' critical and creative thinking skills (Nurjaman & Sari, 2017; Toheri et al., 2020) because they have to solve problems and develop their understanding. Thirdly, Problem posing can increase students' motivation to learn, as they feel they have an active role in learning.

Problem posing has a significant impact on the development of critical thinking skills in students; some of the main impacts of Problem posing on critical thinking skills: students are invited to question and consider complex issues, encourage students to identify the assumptions underlying a problem or situation (Grabinger & Dunlap, 2011), triggering students to think creatively and find innovative solutions. In formulating the questions, students should connect new ideas (Isaksen et al., 2011), consider different points of view, and find unique approaches, enabling students to develop critical evaluation and judgment skills (Lai, 2011; Marshall, 1995), help students develop critical communication skills (Hasanah & Nasir Malik, 2020; Yeen-Ju et al., 2015). Dengan merangsang pemikiran kritis dan melibatkan siswa dalam proses aktif merumuskan pertanyaan, problem posing menjadi alat yang kuat dalam pengembangan kemampuan berpikir kritis. Siswa tidak hanya menjadi konsumen pasif informasi, tetapi juga menjadi pembuat pertanyaan, peneliti, dan penilai informasi secara aktif.

The leading critical thinking theory used in this study is the development of critical thinking proposed by Ennis through six elements of critical thinking, acronym FRISCO (Focus, Reason, Inference, Situation, Clarify, and Overview). (Fisher, 2000; Payan et al., 2015). Here is a brief explanation of focus, reason, inference, situation, clarity, and overview in the context of critical thinking: Focus is the ability to focus on relevant and significant aspects of a problem or situation. Reason refers to using logic and reasonable arguments in critical thinking. This involves identifying premises or assumptions that support a conclusion or opinion and the ability to analyze the strengths and weaknesses of existing arguments. Inference is the ability to make reasonable conclusions based on available information. Situation refers to a good understanding of the context or environment in which the Problem or situation occurs. Understanding the situation helps identify factors that affect the Problem and allows for more accurate judgment. The description refers to the ability to think and communicate clearly and orderly. In critical thinking, it is essential to formulate ideas and arguments clearly so that others can understand our thinking and our evaluations can be made objectively. Overview involves the ability to view a problem or situation holistically, considering the various factors involved and the relationships between them. A good overview helps identify patterns, trends, or implications that might be missed by focusing only on individual details. Using these concepts in critical thinking can help develop more analytical, rational, and systematic thinking in dealing with complex problems or situations.

Literature Review

Mathematical Critical Thinking Skills and Its Research Lines

One method that is often associated with critical thinking skills is STEM. (Priatna et al., 2020), Then guided inquiry (Murnaka et al., 2019) by improving and creating student worksheets (Yasin et al., 2019) and using mathematics learning models to stimulate critical thinking skills. (Setiana et al., 2021), metode berikutnya adalah Concept Attention Model (CAM) (Angraini & Wahyuni, 2020) used open-ended questions and activities based on these preferences to develop students' mathematical critical thinking skills (Monrat et al., 2022), including developing tools to assess mathematical critical thinking skills, especially in the context of higher order thinking skills (HOTS) dan ICT-based interactive learning media (Hidayat et al., 2023), Another method that is also related to mathematical critical thinking skills is Problem-Based Learning (Yohannes et al., 2021). Table 1 presents the research discussed above to make it easier to understand the explanation above.

Table 1. Summary table of the reviewed scientific literature.

Title	Author	Source	Years
STEM education at junior high school mathematics course for improving the mathematical critical thinking skills	Priatna, N., Lorenzia, S.A., Widodo, S.A.	Journal for the Education of Gifted Young Scientists, 8(3), pp. 1173–1184	2020

The guided inquiry to improve students' mathematical critical thinking skills using student worksheet	Yasin, M., Jauhariyah, D., Madiyo, M., ... Irwandani, I., Mardana, F.F.	Journal for the Education of Gifted Young Scientists, 7(4), pp. 1345–1360	2019
Method of guided inquiry learning to improve student's critical thinking abilities in facing the industrial revolution 4.0	Murnaka, N.P., Almaisurie, Q., Arifin, S.	International Journal of Scientific and Technology Research, 8(9), pp. 439–441	2019
The application of mathematics learning model to stimulate mathematical critical thinking skills of senior high school students	Setiana, D.S., Purwoko, R.Y., Sugiman	European Journal of Educational Research, 10(1), pp. 509–523	2021
The Effect of Concept Attainment Model on Mathematical Critical Thinking Ability	Angraini, L.M., Wahyuni, A.	International Journal of Instruction, 14(1), pp. 727–742	2020
Developing Students' Mathematical Critical Thinking Skills Using Open-Ended Questions and Activities Based on Student Learning Preferences	Monrat, N., Phaksunchai, M., Chonchaiya, R.	Education Research International, 2022, 3300363	2022
Development of assessment tools of critical thinking in mathematics in the context of hots	Tanjung, H.S., Nababan, S.A., Sa'dijah, C., Subanji	Advances in Mathematics: Scientific Journal, 9(10), pp. 8659–8667	2020
How can android-based trigonometry learning improve the math learning process?	Hidayat, W., Rohaeti, E.E., Hamidah, I., Putri, R.I.I.	Frontiers in Education, 7, 1101161	2023
The Effect of Problem-Based Learning Model on Mathematical Critical Thinking Skills of Junior High School Students: A Meta-Analysis Study	Yohannes, Juandi, D., Tamur, M.	Jurnal Pengukuran Psikologi dan Pendidikan Indonesia, 10(2), pp. 142–157	2021

The above scholarly analyses are based on the most cited articles using common patterns in publications adopting new research methods and designs with qualitative and quantitative approaches. (Weller, 2014), The various approaches used to maximize mathematical critical thinking skills show that no method is most appropriate for improving mathematical critical thinking skills.

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STEM (Science, Technology, Engineering, and Mathematics) is an educational approach that focuses on the integration of science, technology, engineering, and mathematics (Guzey et al., 2014; Rennie et al., 2012), STEM education provides opportunities for students to develop their critical thinking skills through interdisciplinary approaches and the application of scientific concepts in real-life contexts (Asghar et al., 2012; Bahrain et al., 2018; Nguyen et al., 2020). Through STEM learning, students are encouraged to think critically in solving problems, analyzing data, and making evidence-based decisions. Critical thinking skills are also required in the design and engineering process, where students must consider various factors and make the right decisions. STEM education has a significant positive impact on the development of critical thinking skills in students. Among them: encouraging students to face complex challenges and real-world problems (Nguyen et al., 2020), helping students develop logical reasoning skills and strong argumentation (Koenig et al., 2012; Nnanyereugo Iwuanyanwu, 2020), focusing on deep conceptual understanding in science, technology, engineering, and maths (Robinson et al., 2014), and students are taught to evaluate the validity and reliability of information, encouraging students to collaborate with others in solving complex projects and problems (Jang, 2016). Overall, STEM education provides a learning environment that promotes and hones critical thinking skills in students. In the STEM context, students develop critical thinking skills through exploration, problem-solving, collaboration, and reflection in research, experiments, and real projects.

Method

Type of Research

This research is an experimental study conducted by researchers to determine how much the ethnomathematics-problem possing approach can improve students' mathematical critical thinking skills using two homogeneous classes.

Research Subject

The population in this study was elementary school students. In the study, only five schools were taken as samples of 6 classes. The schools used as samples in this study were schools in the high category, as many as two classes, medium category two classes, and low category two classes with the same ability, in grade V elementary school students, given the effectiveness of the research implementation, where the characteristics of this study are very dependent on the subject under study. The research sample was restricted due to time constraints, so the researchers only used five schools. Determination of the category using stratified sampling based on the average minimum completion score.

Research Instruments

The aspects intended here are Focus, Reason, Inference, Situation, Clarity, and Overview. So this scoring technique is based on the FRISCO thinking aspects of measuring students' critical thinking skills.

Data Analysis Technique

The data analysis technique used in this study was calculated by calculating the normalized gain. Calculating normalized gain is a method to measure the improvement of students' abilities in a particular topic after receiving specific treatment or learning. (Judson & Sawada, 2002). Normalized gain is calculated by comparing the average test score after learning with the average test score before learning; then, the results are normalized by dividing by the difference between the maximum and minimum scores. Furthermore, to test the effectiveness of the application of the Ethnomathematics-Problem Possing approach in improving students' critical thinking skills when compared to conventional learning, a two-way analysis of variance (ANOVA) was conducted.

Result

Improving Mathematical Critical Thinking Skills.

Based on the results of the calculation of the normality test using the Kolmogorov-Smirnov Z test at the significance level $\alpha = 0.05$ on the critical thinking skills of experimental and control class students with testing criteria if significant $< \alpha$, then it is rejected, and if significant $\geq \alpha$ then it is acceptable. The following results of the normality test of critical thinking ability (Gain-1) can be seen in Table 2 below.

Table 2. Normality Test of Gain-1 of Experimental Class and Control Class Third Qualification

Aspects	Normality Test		
	Kolmogorov-Smirnov	Significant (α)	H_0
Critical Thinking Ability	0,079	0,05	Accept

Table 2 shows that critical thinking ability (Gain-1) is usually distributed. This can be seen in the acquisition of the value done with the Kolmogorov-SmirnovZ test where the P-value $\geq$ 0.05. This means that it is accepted. Furthermore, to determine the significance of the difference in mean gain between the experimental and control groups, a two-way ANOVA test was conducted with test criteria based on the Kolmogorov-SmirnovZ test, where the significance value was more significant than $\alpha = 0.05$. The following is a summary of the calculation results in Table 3 below:

Table 3. Homogeneity Test of Gain-1 of Experimental Class and Control Class Third Qualification

Aspects	F	Sig.	H_0
Critical Thinking Ability	2,130	0,065	Accept

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The calculation results in Table 3 show that the variance of the gain score of critical thinking ability of experimental and control classes has a value greater than the significance level $\alpha = 0.05$, so it can be concluded that the variance of the two gains is homogeneous.
Furthermore, the mean score and standard deviation of the pretest, posttest, and critical thinking ability gain (Gain-1) based on school and learning qualifications. The following calculation summary results can be seen in Table 4 below:

Table 4. Critical Thinking Ability Score (Test-1) Based on School and Learning Qualification

Proficiency Test Critical Thinking		School Qualification					
		High		Medium		Low	
		Problem Posing	Conventional	Problem Posing	Conventional	Problem Posing	Conventional
Pre	$\overline{X}$	18,41	18,17	13,29	12,87	10,83	10,11
	SD	2,09	2,30	2,54	1,94	2,46	2,04
Pos	$\overline{X}$	24,45	22,13	20,96	18,57	18,33	14,30
	SD	2,18	3,08	3,13	2,71	3,13	2,28
Gain	$\overline{X}$	0,52	0,33	0,46	0,33	0,39	0,21
	SD	0,16	0,23	0,14	0,16	0,17	0,13

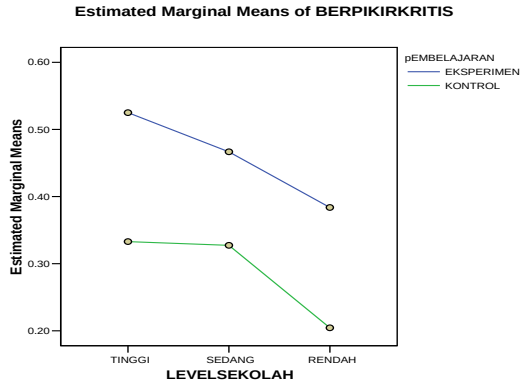
Based on the analysis of Table 4 above, the school qualification factor affects critical thinking skills. Schools with high qualifications tend to obtain better mean scores than schools with medium and low qualifications. However, schools with medium qualifications tend to be better than schools with low qualifications. In addition, the mean scores of the three school qualifications that received learning with the ethnomathematics-problem possing approach increased better than conventional learning. To see the significance of the mean score of the learning approach based on the school qualification category, a two-way Analysis of Variance (ANOVA) statistic was used. Using ANOVA, the summary results obtained are shown in Table 5 below.

Table 5. Results of Two-Way ANOVA Statistical Test of Gain-1 School Qualification and Learning Approach

Factors	Gain Tes-1		
	F	Significance	H_0
School Qualification	8,625	0,000	Reject
Learning	38,117	0,000	Reject
Interaction	0,338	0,714	Accept

H_0 **:** There is no difference in the improvement of critical thinking skills based on school qualifications and learning From Table 5 above, it can be seen that the statement that there is no difference in the improvement of critical thinking skills based on school qualifications and learning is rejected; this means that there is a significant difference in the improvement of students' critical thinking skills. So it can be concluded that there is a difference in improving students' critical thinking skills between students whose learning uses the Ethnomathematics-problem possing approach and those whose learning is conventional. However, no significant interaction exists between school qualifications and learning, as in Table 5 above. Thus, it can be concluded that high and medium school students showed the most significant improvement in critical thinking skills in low-qualification classes. It also appears that the three school qualifications that received learning with the Problem possing approach improved better than students who received conventional learning. More details can be seen in Figure 1 below:

Figure 1. School qualification interaction



Discussion

Based on the results of the study shows that the learning outcomes of students who use the ethnomathematics-problem possing approach have improved better than schools whose learning is conventional; the proper learning method that is tailored to the needs of students can improve student learning outcomes (Cook et al., 2018; Tzenios, 2020), teaching approaches that actively engage students, such as project-based learning, discussion, and co-operation, tend to produce more significant improvements in learning outcomes than passive teaching methods (Hattie, 2012), Effective learning methods are those that facilitate student interaction, involve problem-solving, provide constructive feedback, and encourage critical thinking. Learning methods that are active and require higher-order thinking from students tend to produce better learning outcomes (R. Marzano et al., 2003; R. J. Marzano, 2008; R. J. Marzano et al., 2001),

Effective learning methods are those that encourage students to actively interact with the subject matter, including problem solving, analysing, synthesising and evaluating information (Bloom, B. S., Krathwohl, D. R., & Masia, 1984), effective learning methods are those that accommodate the different types of student intelligence, so that students can learn in ways that suit their individual strengths (Gardner & Hatch, 1989), Other studies also show that learning outcomes are influenced by learning methods, including: Group discussions are more effective than lecture discussions in improving student learning outcomes (Mutrofin et al., 2017), elaborated feedback is more effective than feedback on the correctness of the answer or providing the correct answer in improving learning outcomes, especially for higher-level learning outcomes (Van der Kleij et al., 2015), flipped classroom and reciprocal peer teaching integrated with Google Classroom are effective interventions to improve learning outcomes (Khapre et al., 2021). The results of this study also show that ethnomathematics-problem solving learning improves critical thinking skills. Ethnomathematics learning with a problem-solving approach can improve students' critical thinking skills. Here are some ways ethnomathematics-problem solving learning can improve critical thinking skills: The ethnomathematics approach allows students to relate mathematics to their daily lives and culture. The Problem-solving approach in Ethnomathematics often involves complex and unstructured problems. Students are faced with problems that require critical thinking, analysis, modeling, and deeper exploration of mathematical concepts; Ethnomathematics introduces students to diverse ways of thinking mathematically that come from different cultures. It opens up opportunities for students to develop critical thinking about the differences and similarities among different mathematical systems, ethnomathematics-problem solving learning often encourages students to discuss and cooperate in solving problems, and ethnomathematics-problem-solving learning can be a powerful approach to improving students' critical thinking skills in the context of mathematics. By connecting mathematics to the culture and context of students' lives, students can develop critical thinking that is more in-depth and relevant to solving problems. Can be seen in the average Gain value obtained by each experimental class and control class on both ability tests, namely critical thinking ability for high qualifications experienced an average increase in gain of 0.52, medium qualifications of 0.46, and low qualifications of 0.39 where when compared to the three qualifications in the class whose learning was conventionally, namely for high school qualifications of 0.33, medium qualifications of 0.33 and low qualifications of 0.21. So it is clear that the difference in improvement between the two groups is better in all three qualifications for the class that learns by Problem posing. It can also be seen that there is no interaction between learning and school qualifications for critical thinking skills. This picture shows a relationship between learning and school qualifications to improve student test results, so we can say that Problem possing learning is very suitable for learning mathematics to improve students' critical thinking skills in high, medium, and low-qualified schools. This means that Problem posing learning has a significant effect on improving students' critical thinking skills. Based on the explanation above, it can be said that students who learn with the Problem possing approach show better results in improving mathematical critical thinking skills than in conventional learning. The Problem posing approach can be implemented effectively in mathematics learning with the hope that

students can apply it and often practice solving real-life problems. (Suryanti et al., 2020). Children have high curiosity, so they often ask questions. Through observation of hands-on learning media, as the concept of culture is presented with good design, in this case with a problem-posing approach, their curiosity will be higher and can develop well. (Isrokatun et al., 2019). Hal ini yang memicu terjadinya peningkatan dalam kemampuan berpikir kritis matematis anak. The same research by Shuukwan et al. said that sharpening insights and more profound knowledge is appropriate if learning uses Problem posing. (Leung & Silver, 1997), According to him, many findings in the research say. Problem posing is perfect for applying, especially in teaching mathematics concepts. (Kar, 2016). This is possible because learning has changed from a teacher-centered learning paradigm to learning that emphasizes student activeness and is supported by learning patterns that integrate culture and mathematics in the dances played so that students are faster in capturing and responding to what is observed with the knowledge they have both individually and in groups in class discussions. In line with this, the principle of Problem possing learning provides flexibility for students to make questions independently and find solutions to the answers to them, which trains their thinking skills. Tyler also states that the experience of what is seen and observed through the learning process will provide opportunities for students to acquire more skills or other abilities in problem-solving so that thinking skills can be developed. (Tyler, 1995). If process skills are continuously practiced in learning science, it encourages higher-order thinking behavior because students view science as a discipline of dynamic processes, not just a static set of facts to be memorized. As such, they accept responsibility for continuous learning as independent learners. (Fuad et al., 2019).

Conclusions

Based on the above explanation, we can conclude that students' mathematical critical thinking skills seen based on school levels with high, medium, and low categories have a significant increase in mathematical critical thinking skills after students are taught with a problem-posing approach by integrating mathematical concepts with culture in Ethnomathematics. The opportunity to express responses and questions to the problems given by the teacher in class impacts student learning development. Students are delighted and enthusiastic in conveying ideas and asking questions so problems can easily be solved quickly. This process requires metacognition skills by maximizing their knowledge to analyze the problems presented by the teacher. Thus, students can develop thinking process skills so that critical thinking skills become better. This is different for students who learn conventionally. The critical thinking skills of students at high, medium, and low school levels are still below the average of students who learn using the Problem posing approach. This condition is caused because the teacher is more monotonous in teaching and does not allow students to ask questions, so students are more silent. For this reason, learning is expected to be more student-centered, and the teacher is not only a learner but also a facilitator and guide for students.

Recommendation:

Based on the findings in this study, the researcher recommends that teachers innovate more in designing learning that favors students to develop and improve mathematical critical thinking skills or other abilities and are expected to be able to solve problems related to social or cognitive-related problems.

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