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Implementation of the connected mathematics project learning model on students' mathematical critical thinking ability

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Abstract

Students' low critical thinking ability in learning mathematics is a major problem in research. This needs to be overcome by implementing learning that provides opportunities for students to develop their thinking ability rationally and well-structured in learning mathematics. One learning model that supports this learning is the Connected Mathematics Project (CMP) learning model. This study aimed to describe quantitatively the implementation of the CMP learning model on students' critical thinking ability in mathematics. This type of research is quasi-experimental with a one-group pre-test and post-test post-test design. The research instruments were observation sheets and tests. The results showed that the application of learning observed in 4 meetings in terms of 9 student activities in learning in the sample group met the criteria for being effective. The student's critical thinking ability through the paired t-test showed a significance value of 0.00, which was smaller than the alpha level of 0.05, meaning that there was a significant difference in the average score from the pre-test to the post-test. Furthermore, the n-gain value obtained is 0.36 (medium). Thus, it was concluded that implementing CMP learning on students' critical thinking ability was effective.

Keywords: implementation, CMP, critical thinking, mathematics

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I. Introduction

The progress of science and technology shows the progress of a nation. As a scientific discipline, mathematics is a basic science that can be used to develop science and technology (Bhakti et al., 2018; Hartono & Putra, 2022). Based on Permendikbud No. 20 of 2016 reveals that one of the Graduate Competency Standards for mathematics subjects for students is that students must have critical, productive, creative, independent, collaborative and communicative thinking abilities (Kemendikbud, 2016). In education, mathematics has a very significant role in human life because it is a vehicle or means to improve attitudes and behaviour through critical thinking (Syarifuddin et al., 2021).

Critical thinking abilities are fundamental for students to improve and develop in the mathematics learning process (R. Lestari et al., 2023). Thus, mathematics learning should pay more attention to developing critical thinking ability. Critical thinking is a targeted ability

prioritized in education systems worldwide (Kawuryan et al., 2022). Critical thinking ability is an important learning outcome and the main focus besides mathematical problem-solving ability (Priatna et al., 2020; Saputra, 2020).

Mathematical critical thinking is a mental activity that involves Understanding and formulating problems; collecting, analyzing and clarifying information; formulating and proving conjectures; Drawing a conclusion; Carrying out evaluations; Making decisions; Carrying out estimates and generalizations (Abdullah, 2013; Ahmad, 2017). Critical thinking is a deliberate thinking activity requiring individuals to frame and assess their beliefs and sentiments (Prihartini et al., 2016; Rohani et al., 2022). Thus, critical thinking ability is a student's cognitive process of analyzing problems encountered and identifying and reviewing information to develop strategies for the problems themselves. A student can think critically if the student has a systematic way of thinking, awareness of thinking, and can differentiate truth from errors encountered (Prasetyo & Firmansyah, 2022).

Critical thinking is key to developing other abilities in various future jobs (Susilo, 2022). Critical thinking ability includes an individual's ability to reason effectively, ask main questions and solve problems, analyze and evaluate alternatives to the point of view, reflect critically, and process decisions (Suresman et al., 2023). Critical thinking in learning involves mental processes individuals and groups use to solve problems, make decisions, and learn and discover new concepts. Critical thinking is investigative activities requiring high-level thinking that involves the ability to analyze, synthesize, evaluate and solve problems and generalize (Kurniati et al., 2015).

This critical thinking ability is closely related to students' curiosity because critical thinking can encourage and assist students in discovering something new (Syarifuddin et al., 2021). The indicators of critical thinking ability applied in this study are: (1) Interpreting where, in this case, students understand the problems indicated by writing known or being asked the questions correctly; (2) Analyzing where, in this case, students identify the relationships between statements, and the concepts given in the questions shown by making models and mathematical language and giving explanations appropriately; (3) Evaluate where in this case students' use the right strategy in solving problems, complete and correct in doing calculations; (4) Making inferences where in this case students' make the right conclusions.

Various pieces of information reveal that students' critical thinking abilities are still low. Based on the 2018 Program International Student Assessment (PISA) study results, Indonesia is ranked 73 out of 79 in the mathematics category. The 2018 PISA results have decreased from 2015, where in 2015 it had a score of 386 while in 2018 it was 379 (OECD, 2019). PISA results show that students in Indonesia still lack problem-solving and critical thinking abilities because mathematics in PISA measures problem-solving and reasoning ability, and problem-solving helps students think critically (Asdarina & Ridha, 2020; Mujarwati et al., 2018). Students' critical thinking abilities are in the poor category because students need to be trained in examining, questioning, associating, and seeing consistency in a mathematical problem (Sartika, 2019). Many students still need help to answer the questions asked using indicators of critical thinking ability (Jannah & Budiman, 2022).

The achievement of students' critical thinking ability in mathematics is different than expected. This requires improvements to the learning activities carried out so far. Critical thinking ability can be trained and sharpened through learning mathematics. The learning model that provides the widest opportunity to develop problem-solving and critical-thinking abilities through giving assignments is the Connected Mathematics Project (CMP) model. CMP is a learning model that emphasizes providing assignments related to mathematics, which aims to help students and teachers develop knowledge, understanding and ability, as well as

awareness and appreciation of the enrichment of relationships between parts of mathematics and between mathematics and other scientific disciplines (Lestari, 2017). Learning with the CMP model helps students' mathematical ideas and concepts into real-life life so that students can easily and precisely understand what they are learning.

The CMP Learning Model is designed to help students hone their understanding and thinking ability so that they can continue solving various problems that contain important concepts in mathematics and mathematical ability. The learning stages with the CMP model include launching, exploring and summarizing, which are always led by the teacher to help students increase their understanding of problems and find efficient and effective strategies (Lappan et al., 2002). Learning activities using the CMP Model in mathematics learning can be carried out through (1) launching, where the teacher issues or gives problems to the entire class; (2) exploring, where students in groups collect data, share thoughts, see patterns, make estimates, and develop problem-solving strategies; (3) summarizing, students' convey their ideas and solutions using the strategies used, organize data and find solutions.

The CMP learning model involves students actively discussing and developing each student's thinking abilities. Various previous studies have revealed that applying the CMP model provides satisfactory results in mathematics learning. Research (Zuningsih, 2017) concluded that the reflective thinking abilities of students who were given the CMP learning model were higher than the learning achievements of students who were given the conventional learning model. Research by (Sartika and Ifa'i, 2018) revealed that the application of the CMP model can improve students' mathematical creative thinking abilities. Furthermore, research Lestari (20 by 17) found that the application of the CMP model in mathematics learning had a significant influence on students' mathematical problem-solving

From the previous description, research on teaching mathematics ability is still very limited, and research still needs to be carried out regarding applying the CMP model for teaching critical thinking ability. This research is important to obtain the latest information regarding the achievements of students' critical thinking ability in mathematics learning through the CMP learning model, which can be a reference for mathematics teachers in learning activities and other researchers who will develop science. The problem formulation is: 1) How do you apply the CMP learning model in learning critical thinking ability? 2) How effectively are students' mathematics critical thinking abilities taught using the CMP model?

II. Research Method

This quantitative research quantifies the ability of students' mathematical problem-solving and ML critical thinking abilities, taught using the Connected Mathematical Project (CMP) learning model. To carry out the research, a quasi-experimental research was carried out with a one group pre-test post-test design. The research design involved 1 class in the study. Sugiyono's research design (2016) can be observed in Figure 1.

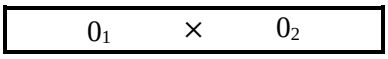

Figure 1. Research design

Information:

0_1 = Critical thinking ability pre-test
0_2= Critical thinking ability post-test
×= Connected Mathematics Project

The place of research is MTsN 1 Padangsidimpuan Jl. Sutan Soripada Mulia No. 27 Padang Sidempuan, Kec. Padangsidimpuan Utara, Padangsidimpuan City, North Sumatra Province. The research population was class VIII students' of MTsN 1 Padangsidimpuan, consisting of 11 study groups. Then, a random sample class will be appointed using the Cluster Random Sampling technique, with the selected class being class VIII-11. The number of students in class VIII-11 is 33 people, with 15 boys and 18 girls.

The research mechanism followed the research design, starting from the research preparation stage, validation and testing of devices and instruments, research data collection and data analysis. The research design was carried out to design research instruments, which included learning observation sheets and research instruments. In addition, learning tools are also designed, which include learning implementation plans and student worksheets. Instruments and devices designed in alphabetic form for grade VIII junior high school students. 4 validators with valid conclusions have validated the design results of these devices and instruments and can be used as a data collection tool. Then, the critical thinking ability test, which is used as a data collection tool, has been tested and declared to meet valid and reliable criteria.

Research activities or data collection begins with an initial test (Pre-test), which includes giving tests of students' mathematical critical thinking abilities to the research sample. After giving the pre-test, learning with the CMP model is carried out in 4 meetings, each with a time allocation of 2×40". After the data is collected, it is analyzed using descriptive and inferential statistics.

Analysis of the observed data was carried out by paying attention to the level of effectiveness of each component, which was observed against 5 (five) people in the observed sample group. The percentage of activity determines the acquisition of a) reading/understanding LAS = 10%; b) finding ways to solve problems = 10%; c) solving problems = 20%; d) asking questions = 5%; e) demonstrating ideas/results=10%; f) discussion among students' = 25%; g) discussions with teachers = 5%; h) records relevant matters = 10%; i) make a conclusion = 5%. Achievement of the effectiveness of learning activities if the percentage is obtained in the percentage of each activity with a tolerance limit of 5%. Inferential statistical analysis was performed by analyzing the normality and homogeneity of the data variants, followed by a paired t-test. The effectiveness level analysis was determined based on the Normalized N-Gain Average value by consulting it on the effectiveness level criteria based on normalized N-gain (Hake, 1999) with the Effectiveness Interpretation of $N - gain < 3$ (Low), $3 \leq N - gain < 7$ (Medium), $N - gain \geq 7$ (High).

III. Results and Discussion

The implementation of the research is adjusted to the research design, which consists of tests and implementation of learning accompanied by observations. Implementing the CMP learning model is based on material in algebraic forms in the sub-topic of simplifying and using algebraic forms. The implementation of learning mathematics with the CMP learning model can be carried out through the initial, core, and final stages. Students are involved in learning individually and in groups at the core stages of learning activities, each group consisting of 4-5 people. The core stages of learning are carried out, including Launch, Explore, and Summary.

Oband reservation of active student activity in the research sample group, which was carried out in 4 meetings with groups randomly selected to be observed consisting of 5 (five) people, can be observed in Table 1.

Table 1.
Obtain the percentage (%) of the results of observing the implementation of the CMP learning model.

Observed activity	Meeting (%)				Average
	I	II	III	IV	(%)
(a) Read/understand student worksheets	12,5	11,3	8,75	7,5	10,0
(b) Find a way to solve the problem	13,8	10	6,25	7,5	9,4
(c) Solve the problem	12,5	18,8	20	23,8	18,8
(d) Ask questions	6,25	7,5	11,3	7,5	8,1
(e) Demonstrate ideas/results	10	7,5	10	10	9,4
(f) Discussion among students	22,5	18,8	21,3	26,3	22,2
(g) Discussion with the teacher	6,25	11,3	13,8	7,5	9,7
(h) Record relevant matters	8,75	10	6,25	3,75	7,2
(i) Draw conclusions	7,5	5	2,5	6,25	5,3

From the table above, it can be noted that at the first meeting of the 9 activities observed, there were 8 activities that met the tolerance limits, and there was one that did not meet the tolerance limits, namely solving problems. This is

because students are less accustomed to learning through solving problems. Where previously, the learning activities carried out tended to be conventional.

At the second meeting of the 9 activities observed, 7 activities met the tolerance limits for active student activity, and 2 of them did not meet the tolerance limits. Those that do not meet the tolerance limit are discussions among students that are too low and discussions with teachers that are too high. In this case, it can be understood that the two aspects are interconnected. Where when the discussion between students and the teacher is dominant, the discussion among students becomes recessive. Where students tend to pay attention to what is conveyed by the teacher, and cooperation with group friends is reduced.

At meeting III, of the 9 activities observed, 7 aspects were observed to meet tolerance limits. At the same time, 2 aspects do not meet the tolerance limit, namely asking questions and discussing with the teacher. Asking questions and discussing with the teacher both exceed the existing tolerance limit. Asking questions, in this case, is a learning activity in the form of question and answer, which is carried out by starting with the student as the questioner. So, the acquisition of the results of observations of the acquisition of scores for asking questions is directly proportional to the discussion with the teacher.

Of the 9 aspects observed at meeting IV, 8 met the tolerance limit. One of the 9 aspects does not meet the tolerance limit, namely recording relevant matters. Regarding the 8 aspects that meet the tolerance limit, the dominant one appears is the aspect of solving problems. In this way, students solve the questions in learning activities. So, the process of recording relevant things is neglected. The graph of the percentage of active student activity from "a" to "i" in learning, as in Table 1, can be seen in Figure 2.

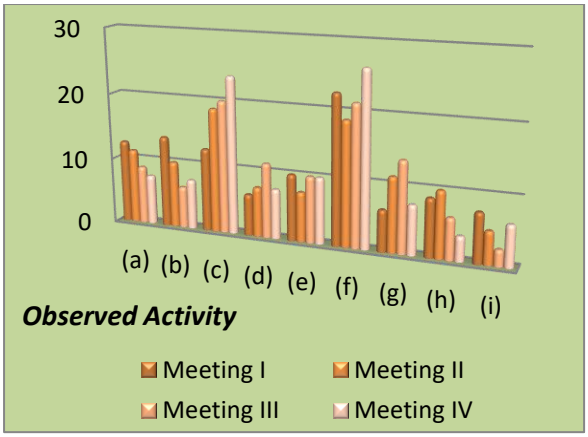

Figure 2. Graph of achievement percentage of student activity in learning

Furthermore, by paying attention to the average of the 9 activities observed from the four learning meetings that were carried out, they met the tolerance limit. Thus, implementing the connected mathematic project model in teaching students critical thinking ability is effective. The same thing was also conveyed. The same thing was also conveyed. (Irawan & Mirliani, 2022) revealed that implementing learning using the CMP model in improving students' critical thinking ability in mathematics was carried out effectively, marked by increased student learning activities and decreased activities carried out by educators. Furthermore, with the connected mathematics project learning model, Sartika and (Rifa'i, 2018) revealed positive student activity during mathematics learning.

The CMP is a learning model that involves launching, exploring and summarizing the learning process. The teacher in learning becomes a motivator, the teacher and a facilitator for students. This activity is carried out individually or in groups. In teaching students critical thinking ability through CMP, students actively learn by solving problems presented through student worksheets. Students are more enthusiastic and positively respond to learning mathematics because they are given a problem and actively search, investigate, and express their own mathematical ideas in solving mathematical problems (Rohendi & Dulpaja, 2013).

Problems are launched to students in study groups. Regarding the problems launched, students will pay close attention to them and try to understand them with focus, both individually and in groups. Students work collaboratively, enabling them to tackle more complicated and conceptual problems (Rupalestari et al., 2018). In this stage, students individually will try to solve problems by trying their strategies individually. With the provision of a mathematics project, it is hoped that learning can be focused on material that is considered important and students can be more responsible for completing a given project according to the division of roles within their group (Daniel et al., 2021).

The problems presented to students become projects that students will solve in learning. Students' critical thinking ability will affect their ability to solve problems and achieve success (Rizti & Prihatnani, 2021). students will discuss various techniques, strategies and methods needed to solve problems. This stage involves students exploring their knowledge to solve more complex problems (Rupalestari et al., 2018). students in learning pose their problems to each other and work collaboratively to find solutions that make sense based on the context (Díez-Palomar et al., 2006). Problems that groups of students cannot solve can be asked of the teacher. Even though the problems presented in learning are taken from real life, students cannot always solve them correctly as a whole. In this case, the teacher will provide scaffolding for problems that groups of students cannot solve'. Student activities independently and in groups in learning will only be assisted by the teacher to the extent of developing idem mathematics (Lappan et al., 2002).

After the problem can be solved in small groups, problem-solving is presented in a larger group. This activity can be done by demonstrating the results obtained in front of the class. This aims to foster an understanding of new and diverse knowledge related to the material being studied, which is carried out by asking students questions and answers. Students in other groups will provide responses and comments on statements that are not in accordance with the understanding of individual students or groups of students. Students are given the widest possible opportunity to build their mathematical knowledge (Irawan & Mirliani, 2022). In this case, students issue arguments to each other to account for their performance. This process will lead to the best solution to the problem presented. In order to carry out these question and answer activities students' must master the concept, analyze, synthesize and evaluate the problem being discussed, in other words the question and answer is carried out because of students' critical thinking processes (Kurniati et al., 2015).

Implementing the tests, which included pre-test and post-test in a sample class, students provided data on student achievement in the pre-test and post-test of students' Mathematical Critical Thinking Ability (MCTA), which descriptively can be seen in Table 2 below.

Table 2.
Descriptive acquisition of student MCTA data

Test	Pre-test MCTA	Post-test MCTA
N	33,00	33,00
Mean	42,54	51,30
Median	43,00	51,00
Mode	43,00	49,00
Std. Deviation	3,85	2,89
Variance	14,82	8,34
Minimum	36,00	46,00
Maximum	51,00	57,00

The descriptive analysis results show that the mean, median, mode, minimum and maximum obtained better results in the post-test than in the pre-test. In other words, the average post-test score is higher than the pre-test score. To see the significance of whether the CMP learning model affects teaching students' ability to understand mathematical concepts, it is analyzed using the Paired Samples Test. For this test, it is first shown that the variance of the data is normally distributed and homogeneous. Obtaining data from the pre-test and post-test were analyzed for the normality level with nonparametric tests with the help of SPSS 20. By

proposing the hypothesis, H_0 = data variance is normally distributed, and H_a = data variance is not normally distributed. With the decision-making criteria, accept H_0 and reject Ha if the significance is > 0.05 or vice versa. The SPSS output of the normality analysis is in Table 3.

Table 3.
Results of normality test analysis

Test	Pre-test MCTA	Post-test MCTA
Asymp. Sig. (2-tailed)	0,82	0,65

The data obtained from the One-Sample Kolmogorov-Smirnov Test showed that the 2-tailed significance was greater than the alpha level of 0.05, thus giving a decision that H0 was accepted. In other words, the data resulting from the ability to understand students' mathematical concepts from the pre-test and post-test have normally distributed variants. Furthermore, on the data on the ability to understand students' mathematical concepts, data homogeneity was analyzed using the Levene statistical test by submitting the hypotheses H_0 = homogeneous data variant and H_a = non-homogeneous data variant. The decision-making criterion is to accept H_0 and reject H_a if the significance is > 0.05 or vice versa. The SPSS output of the normality analysis is in Table 4 below.

Table 4.
Obtained homogeneity test significance value

Test	Post test-Pretest MCTA
significance	0,33

The data obtained from the Test of Homogeneity of Variances shows that the significance is greater than the alpha level of 0.05, which gives a decision that H_0 is accepted. With this, the variance of the pre-test and post-test data for students' ability to understand mathematical concepts is homogeneous. Thus, the significance of implementing realistic mathematics education can be analyzed by paired t-test. The test was carried out by submitting hypotheses H_0 = no average difference between the pre-test and post-test results and H_a = an average difference between the pre-test and post-test results. With the decision-making criteria, accept H_0 and reject Ha if the significance is > 0.05 or t-count <t-table and vice versa. The SPSS output of the t-test analysis is in Table 4 below.

Table 5.
Obtain the significance value of the paired t-test

Test	Post test-Pretest MCTA
Asymp. Sig. (2-tailed)	0,000
df	32
t-count	71,45
t-table	2,06

Obtaining significant data (2-tailed) 0.00 <0.05 and t-count > t-table (71.45> 2.06) gave the decision to reject H_0 and accept H_a. This means a significant average difference exists between the pre-test and post-test results. In other words, the implementation of the CMP learning model has a significant influence on teaching students critical thinking ability. The findings of this research align with the findings of (Harahap 2020), which reveal a significant influence of the CMP learning model on students' mathematical representation abilities on function limits. The results of research (Zuningsih, 2017) concluded that learning mathematics through the CMP learning model had an effect on students' reflective thinking abilities, and it was also found that the average value of students' reflective thinking abilities who were taught using the CMP learning model was higher than the average value of thinking abilities. Reflective of students taught using conventional learning models.

The average score for critical thinking ability in mathematics from the post-test was significantly higher than the pre-test. If it is related to implementing learning using the CMP model, then this model applied in teaching critical thinking ability in mathematics has a significant positive influence. This is because the learning activities carried out have a problem-solving stage in student worksheets, which are carried out in groups. Teachers in learning provide opportunities for students to convey their knowledge and experience in solving problems so that other students gain the knowledge and

experience they have (Maryati, 2017). students in group learning can better understand and solve problems contained in student worksheets properly and correctly. Students are responsible for completing a given student worksheet project according to their role in the group (Rohendi & Dulpaja, 2013).

Critical thinking skills, which involve interpreting, analyzing, evaluating, and interpreting, have a positive influence through the stages contained in the CMP model, which include launching, exploring, and summarizing. Learning activities involve carrying out assignments that require students to use the concept of connections between various mathematical materials and mathematical materials with other scientific disciplines. Interpreting activities in the CMP learning model occur because, at the beginning of the learning activity, students are already faced with problems in the form of tasks that require them to be solved. Interpreting activities will arise as students respond to the launching problem in learning. By launching mathematical problems, students are enthusiastic about interpreting problems. In this case, students are focused on identifying problems by focusing on questions and elements contained in the problem (Apiati & Hermanto, 2020). This makes students accustomed to interpreting problems that involve determining what is known and what is asked.

Furthermore, based on existing problems, students explore the problem in order to get the solution. This involves activities in formulating relationships from existing statements. This activity will bring students into the activity of evaluating the problem. Students will take actions that are shown to make mathematical models both independently and with group members according to their understanding (Prajono et al., 2022). In this case, students will understand the relevance of the concept statements found. This activity involves determining the relationship of statements to be applied in decision-making. Through this stage, students will find relationships from existing statements. In this stage, critical thinking is done by identifying the relationships between the concepts in the problem by creating a mathematical model and appropriate explanation (Apiati & Hermanto, 2020). The relationship of these statements will form a concept that can eventually form a formula. In this case, students will make a mathematical model according to the results. In other words, students will form mathematical models well. The critical thinking skills students possess will make it easier for them to solve problems and find the best solutions to solve problems (Pertiwi et al., 2023).

The mathematical modelling obtained will be tested for the values contained in certain statements. This involves the ability to analyze the right strategies and methods to obtain problem-solving. In solving problems, it is necessary to use a strategy/how to solve problems quickly and accurately (Prajono et al., 2022). Students analyze assumptions to make decisions in solving problems. This activity involves the use of correct and logical calculation processes. In other words, students can critically analyze information to solve problems in solving a problem (Nurdin et al., 2020). This activity is an advanced exploration for students to solve problems that require teacher directions so that mathematical problem-solving results are found using good processes and correct results.

After solving the problem is found, it is necessary to make inferences about the findings of solving the problem. Differentiating activities are carried out by associating problem-solving results with previous problems. In this stage, students are able to make conclusions from solving the problems that are carried out. This is done to get the meaning of existing problem solving and increase understanding of the solution to the problem. Furthermore, the normalized N-gain obtained from the value of the ability to think creatively through the pre-test and post-test is 0,36. This value is in the medium category. Thus, it was concluded that implementing the Connected Mathematics Project increased students' critical thinking ability. The same thing was also conveyed in the results of classroom

action research by (Irawan & Mirliani, 2022), which revealed that the application of the CMP model could improve students' critical thinking ability with indicators of identifying problems, generalizing and analyzing algorithms which could be observed from the pre-test results, only 5 students' achieved good category. Furthermore, in the post-test results, 26 students' had reached the good category. The next research by Sartika and (Rifa'i, 2018) in the quasi-experimental research revealed that there was a significant increase in the ability to think creatively in mathematics using the connected mathematics project learning model. This can be seen from the average results before and after learning, which can be observed through the results of the experimental class for the pre-test getting an average of 18.57 and post-test getting an average of 50.64 so from the average of pre-test and post-test there is an increase of 32.07.

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IV. Conclusion

Based on the research results and discussion, it was concluded that implementing the CMP learning model on students' critical thinking ability in mathematics was effective. The CMP Learning Model is applied well to teach students critical thinking ability in mathematics. Through launch, exploration and summary activities, students learning mathematics actively interpret problems, analyse various relationship statements, evaluate possibilities and infer solutions. Apart from that, the CMP model can create an atmosphere for students to be active, enthusiastic, communicative and enthusiastic in learning activities during group discussions and inter-group discussions. In learning activities, students solve the problems presented both independently and in groups. Students solve problems by providing constructive ideas and ideas to solve the problem critically so that a complete and correct solution to the problem is obtained. Thus, it is recommended that teachers consider the CMP learning model, especially in improving mathematical thinking ability. Furthermore, other researchers can conduct broader and more in-depth research related to implementing the CMP learning model.

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