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The Influence of Connected Mathematics Project (CMP) Learning Models on Student's Mathematical Communication Ability in View of Self Esteem

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Abstract

This study examines the effectiveness of the Connected Mathematics Project (CMP) learning model in improving students' mathematical communication skills at MA Madarijul Huda Pati. Because of 46.15% of students demonstrating very low skills and 23.07% falling into the low category, the study aims to: (1) analyze the impact of CMP on mathematical communication skills, (2) compare skills among students with high, moderate, and low self esteem, and (3) explore the interaction between CMP and self esteem. Employing a quantitative quasi-experimental approach, the study involves class XI students selected through cluster random sampling. Results indicate a significant improvement in mathematical communication skills through CMP. Students with high self esteem outperform those with moderate self esteem, while those with moderate self esteem fare better than those with low self esteem. Additionally, students with high self esteem exhibit superior mathematical communication skills compared to students with low self esteem. Notably, an interaction between the learning model and self esteem was observed, influencing mathematical communication skills.

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INTRODUCTION

Apart from playing an important role in everyday life, mathematics is also a compulsory subject studied at various levels of education. The ability to communicate mathematically is a crucial component that students must possess when learning mathematics. In the classroom setting, mathematical communication can occur between teachers and students, between textbooks and students, and among students themselves (Purnama & Alfriansyah, 2016). The National Council of Teachers of Mathematics (NCTM) (2000) suggests that one of the objectives of learning mathematics is to develop mathematical communication skills. Additionally, Regulation of the Indonesian Minister of National Education Number

22 of 2006 concerning Content Standards states that one of the goals of learning mathematics is for students to be able to communicate ideas using symbols, tables, pictures, or other media to clarify situations or problems.

The CMP learning model is an instructional approach that emphasizes learning tasks to actively engage students and promote discussions, thereby enhancing their mathematical communication skills. However, based on observations at MA Madarijul Huda Pati, teachers still predominantly employ direct instruction and do not utilize a variety of learning models. Consequently, students tend to be passive and do not actively participate in the learning process. A significant percentage of students at MA Madarijul Huda Pati have mathematical communication skills categorized as very low (46.15%) or low (23.07%). These statistics indicate that the desired goals of mathematics education have not been adequately achieved. The Program for International Student Assessment (PISA) survey conducted in 2018 revealed that Indonesia ranked 73 out of 78 participating countries, with an average score of 379, compared to the OECD average score of 489 (OECD, 2019). Furthermore, Fitria and Handayani (2020) found that students' communication skills in Indonesia are still categorized as low, while Yanti, Melati, and Zanty (2019) reported that students' communication skills, particularly in answering questions, are relatively low.

The success of mathematics education can be measured by students' mathematical communication skills. Yuniarti et al. (2018) conducted research showing a positive relationship between students' mathematical communication skills and their self esteem. Aspriyani (2020) also found that students with higher self esteem tend to have higher mathematical communication skills. As educators, teachers are expected to enhance self esteem as an effort to improve students' mathematical communication skills during instruction. Choosing the appropriate and innovative learning model in mathematics education is a fundamental necessity. According to Ziana and Ristontowi (2020), the CMP learning model is an effective approach for improving mathematical communication skills. By implementing the CMP learning model, it is hoped that a conducive learning environment can be created where students gain independence in expressing ideas, asking questions, and solving problems, thereby supporting the enhancement of their mathematical communication skills.

Based on the aforementioned background, the research questions are as follows: (1) How does the CMP learning model influence students' mathematical communication abilities? (2) Are there differences in mathematical communication skills among students with high, moderate, and low self esteem? (3) Is there an interaction between the CMP learning model and self esteem regarding mathematical communication skills? The objectives of this study are to (1) analyze the impact of the CMP learning model on students' mathematical communication skills, (2) compare mathematical communication skills among students with high, moderate, and low self esteem, and (3) examine the interaction between the CMP learning model and self esteem in relation to mathematical communication skills.

RESEARCH METHODS

This study used a quantitative approach with experimental research methods. The independent variables in this study were learning models and self esteem, while the

dependent variable used was students' mathematical communication skills. The population used in this study were students of class XI MA Madarijul Huda Pati. The sampling technique used is cluster random sampling, namely group sampling, where the units selected are not individuals, but a group of individuals who are naturally together in one place. In this study, samples were taken using random samples with a lottery system so that each class had the same opportunity to be sampled in the study. The technique is to draw a roll of paper for a number of classes with the class number written on it, so that one experimental class and one control class are obtained. Data collection used instruments in the form of self esteem and mathematical communication ability test questions. The data analysis technique in this study is the two-way ANOVA test.

Connected Mathematics Project (CMP) Learning Model

The measurement scale in this study used a nominal scale with two categories, namely the CMP learning model in the experimental class and the direct learning model in the control class.

The CMP learning model is a learning model in which students are given the opportunity to develop and create their own knowledge by finding solutions to the given problems and then ending with discussions in class to ensure knowledge and obtain more effective and efficient solutions. The most basic difference between the CMP model and other models is that the CMP model has simple learning steps, as according to Lappan et al. (2002), the steps of the CMP learning model are launching problems, exploring, and summarizing. While the direct learning model is a simple learning model in which the teacher explains the subject matter directly to students and students listen. The steps of the direct learning model according to Slavin (2018), namely: informing learning objectives and lesson orientation to students, reviewing prerequisite knowledge and skills, conveying subject matter, implementing guidance, providing opportunities for students to practice, assessing performance and providing feedback back, as well as providing self-training.

Mathematical Communication Ability

Mathematical communication ability is an ability to express mathematical ideas or ideas in a structured manner with the aim of providing interpretation. The indicators of mathematical communication skills used in this study are based on Brenner (1998) which has been modified: (a) Problem solving tool, expressing problems into written mathematical ideas followed by writing complete and structured problem solving steps; (b) Alternative solution, providing an interpretation of the results of problem solving that has been obtained by writing conclusions. Use the results that have been obtained to solve other mathematical problems if needed.

In the problem solving tool indicator, students are expected to be able to write down mathematical ideas and steps to solve problems related to the problem of determining sigma notation and mathematical induction completely and accurately. Whereas in the alternative solution indicator, students are expected to be able to write conclusions based on the results of the completion previously obtained completely and correctly.

Data collection was based on the results of the pretest and posttest of mathematical communication skills in the form of a mathematics induction material

description test which was implemented using the CMP learning model and direct learning.

Self Esteem

Self esteem is a self-assessment made by individuals towards themselves positively based on relationships with other people, so that their behavior reflects what the individual values and how individuals accept themselves. Students' self esteem is measured through a questionnaire based on Rosenberg (1965) Self Esteem Scale. RSES (Rosenberg Self Esteem Scale) consists of ten statement items. The scale used in this study consists of unfavourable items and favorable items. Favorable statements are statements that contain positive or supportive things about the attitude object. An unfavorable statement is a statement that contains negative things, namely not supporting the object of the attitude to be expressed.

RESULT AND DISCUSSION

The central tendency of the pretest posttest data of mathematical communication ability in the control class (direct learning model) and the experimental class (CMP learning model) is presented in Table 1.

Table 1. Central Tendency

Central Tendency		X_{min}	$\bar{X}$	M_e	M_o	X_{max}	SD
Control class'	Pretest	13.33	22.50	23.33	26.67	30.00	5.01
	Posttest	40.00	60.21	60.00	60.00	73.33	8.33
Experimental class	Pretest	16.67	22.50	26.67	33.33	4.49	4.49
	Posttest	50.00	73.12	76.67	76.67	90.00	10.47

The results of filling in the student self esteem questionnaire were processed and then classified into three self esteem groups namely high, moderate and low categories. In the experimental class there were 14 students with high self esteem, 14 students with moderate self esteem, and 3 students with low self esteem, while in the control class there were 9 students with high self esteem, 15 students with moderate self esteem, and 8 students with low self esteem.

Table 2. *t*-test Analysis

Statistics	Direct Learning Model	CMP Learning Model
Sum	720.00	796.67
Average	22.50	25.70
Standard Deviation	5.01	4.49
Variance	25.09	20.14
$S_{combined}$	28.07	
$\sqrt{\frac{n_1 + n_2}{n_1 \, x \, n_2}}$	0.25	
t_{count}	-0.45	
t_{table}	2.00	

In the initial data analysis, the pretest data for the control class and the experimental class are normally distributed and homogeneous. Based on the results of the *t*-test calculation, the pretest data average value of the experimental class' communication skills is comparable to the control class. The results of processing the *t*-test data are presented in Table 2.

The calculation of the t-test uses a significance level of 5%, where the t_{count}=-0.45 and t_{table}=2.00 are obtained. Based on the results of calculating the value of $t_{count}<t_{table}$, then is accepted, which means that the pretest average value of the experimental class' communication skills is comparable to the control class.

During the final data analysis, it was observed that the posttest data in both the control class and the experimental class exhibited normal distribution and homogeneity. Furthermore, the data for students with high, moderate, and low self esteem also followed a normal distribution and displayed homogeneity. The hypothesis testing involved conducting a two-way ANOVA test to compare the differences in data influenced by two independent variables, namely the learning model and self esteem. The results can be seen in Table 3.

Table 3. Summary of Two-Way ANOVA Test Analysis Results

Source	*JK*	*DK*	*RK*	F_{obs}	F_{α}	Test Decision
Learning Model (A)	868.08	1	868.08	11.72	4.01	H_{0A} is rejected
Self Esteem (B)	1262.02	2	631.01	8.52	3.16	H_{0B} is rejected
Interaction (AB)	670.38	2	335.19	4.52	3.16	H_{0AB} is rejected
Error	4223.16	57	74.09	-	-	-
Total	7023.64	62	-	-	-	-

Based on Table 3, the value $F_{obs(A)}$=11,72>$F_{\alpha(A)}$=4,01; $F_{obs(B)}$=8,52>$F_{\alpha(B)}$=3,16; and $F_{obs(AB)}$=4,52>$F_{\alpha(AB)}$=3,16. From the results of these calculations, a test decision can be taken, namely H_{0A} is rejected, H_{0B} is rejected, and H_{0AB} is rejected. Due to the rejection of the hypothesis, further tests were carried out using the Scheffe test.

The Scheffe test was carried out as a follow-up test of the two-way Anava which aims to find out which treatment pairs are significantly different due to the rejection of H_0. The follow-up test in this study used the mean comparison between rows to answer hypothesis 1, the mean comparison between columns to answer hypothesis 2, and the mean comparison between cells in the same column to answer hypothesis 3 on two-way ANOVA. The results of the mean test between rows to answer hypothesis 1 are presented in Table 4.

Table 4. Comparison of Means Between Rows

Learning Model	Self Esteem			Marginal Mean
	High	Moderat	Low	
CMP Learning	78.33	71.43	56.67	68.81
Direct Learning	61.85	60.22	58.33	60.14
Marginal Mean	70.09	65.83	57.50	-

Based on Table 4, the marginal mean value in answering hypothesis 1 for treatment using the CMP learning model is 68.81 and the marginal average for treatment using the direct learning model is 60.14, which means that 68.81>60,14.

This means that the mathematical communication skills of students who get learning using the CMP model are better than students who get learning using the direct model.

Furthermore, the mean comparison table between columns to answer hypothesis 2 is presented in Table 5.

Table 5. Comparison of Means Between Columns

Comparison	Computing	Critical Area	Test Decision
μ_1 vs μ_2	6.77	$\{F\|F>6.32\}$	μ_1 is better μ_2
μ_2 vs μ_3	6.47	$\{F\|F>6.32\}$	μ_2 is better μ_3
μ_1 vs μ_3	19.70	$\{F\|F>6.32\}$	μ_1 is better μ_3

Note: μ_1=Students' mathematical communication skills with high self esteem; μ_2=Students' mathematical communication skills with moderate self esteem; μ_3=Students' mathematical communication skills with low self esteem.

Based on Table 5, the value $F_{1\text{-}2}$=6.77; $F_{2\text{-}3}$=6.47; dan $F_{1\text{-}3}$=19.70. The critical area in the mean comparison test between columns gets the value $\{F|F>6.32\}$ and in determining the test decision can be done by comparing F_{obs} with the critical area. Thus, there appears to be a significant difference in μ_1 and μ_2, μ_2 and μ_3, and μ_1 and μ_3. This means that students with high self esteem categories have better mathematical communication skills than students who have moderate self esteem categories, students with moderate self esteem categories have better mathematical communication skills than students who have low self esteem categories, and students with high self esteem category has better mathematical communication skills than students who have low self esteem category.

The results of average comparisons between cells in the same column to answer hypothesis 3 is also presented in Table 6.

Table 6. Comparison of Means Between Cells in the Same Column

Comparison	Computing	Critical Area	Test Decision
μ_{11} vs μ_{21}	20.09	$\{F\|F>11.9\}$	μ_{11} is better μ_{21}
μ_{12} vs μ_{22}	12.27	$\{F\|F>11.9\}$	μ_{12} is better μ_{22}
μ_{13} vs μ_{23}	0.08	$\{F\|F>11.9\}$	μ_{13} is better μ_{23}

Note: μ_1=The CMP learning model and high self esteem towards mathematical communication skills; μ_{12}=The CMP learning model and moderate self esteem towards mathematical communication skills; μ_{13}=The CMP learning model and low self esteem towards mathematical communication skills; μ_{21}=The direct learning model and high self esteem towards mathematical communication skills; μ_{21}=The direct learning model and moderate self esteem towards mathematical communication skills; μ_{21}=The direct learning model and low self esteem towards mathematical communication skills.

Based on Table 5, the value $F_{11\text{-}21}$=20.09; $F_{12\text{-}22}$=12.27; and $F_{13\text{-}23}$=0.08. The critical area in the mean comparison between cells in the same column gets the value $\{F \mid F>11.9\}$. In determining the test decision can be done by comparing the F_{Obs} with the critical area. There are significant differences in μ_{11} and μ_{21}, and μ_{12} and μ_{22}. This means that Students with high, moderat, and low self esteem who get the CMP learning model have better mathematical communication skills than students with high, moderat, and low self esteem who get learning with the direct learning model.

Students' Mathematical Communication: CMP vs. Direct Learning Model

From the calculation results of the ANOVA test for two different treatment groups, the observed *F*-value ($F_{Obs(A)}$) is 11.72, which is greater than the critical *F*-value ($F_{\alpha(A)}$) of 4.01. Therefore, we can conclude that the null hypothesis H_{0A} is rejected, indicating that the learning model has an effect on students' mathematical communication skills. Based on the results of the mean comparison between groups, it is evident that the average score for the CMP learning model is 68.81, while the average score for the direct learning model is 60.14. This indicates that students who received the CMP learning model exhibited better mathematical communication abilities compared to those who received the direct learning model.

Factors that can cause students in classes taught using the CMP model to have better mathematical communication skills, because (1) student-centered learning, (2) learning is carried out in groups, so students can cooperate in solving the problems given, and (3) there are discussions with group members so that students can communicate both orally and in writing. In addition, the steps in the CMP learning model are also able to facilitate students to improve their mathematical communication skills as shown by the posttest results of mathematics.

Students who get learning using direct learning models are less enthusiastic about participating in the learning process. During the learning activities students only listen, listen, and record the material delivered by the teacher. Students tend to be passive and less enthusiastic about participating in learning activities. Relevant previous research, namely research conducted by Ziana and Ristontowi (2020) which states that the CMP learning model has an average result of mathematical communication skills that is better than conventional learning models. Apart from that, Isnani, Masykur, and Andriani's (2021) research also states that there is an influence between the CMP learning model and conventional learning on mathematical communication skills. Students who get CMP learning get better results than students who get conventional learning.

Students' Mathematical Communication Skills and Levels of Self Esteem

From the calculation results of the ANOVA test for two different groups, the observed *F*-value ($F_{Obs(B)}$) is 8.52, which is less than the critical *F*-value ($F_{\alpha(B)}$) of 3.16. Therefore, we can conclude that the null hypothesis H_{0B} is rejected, indicating that there is a significant difference between high, moderate, and low self esteem levels in relation to students' mathematical communication skills. After conducting the Scheffe test for mean comparisons between groups, it was found that students with high self esteem demonstrate better mathematical communication skills compared to students with moderate self esteem. Similarly, students with moderate self esteem exhibit better mathematical communication skills compared to students with low self esteem. Additionally, students with high self esteem show better mathematical communication skills than students with low self esteem.

Students with high self esteem categories are more active than students with moderate self esteem categories. Students with high category self esteem tend to be more able to face learning interactions in class, skilled, and confident in their abilities. Even though they need to be provoked, students with moderate self esteem categories are able to face learning interactions in class and are confident in their abilities. Meanwhile, students with low self esteem are more doubtful and have low self esteem. Students with low self esteem also tend to be passive and avoid social

interactions with teachers and other students. Research by Elviani, Sugiatno, and Sayu (2020) states that students with high self esteem relatively have high mathematical communication abilities, while students with moderate self esteem have moderate mathematical communication skills. The results of research by Mahani, Budiyono, and Pratiwi (2019) also state that students with high self esteem have better mathematical communication skills than students with moderate self esteem. This is also reinforced by the research of Rahmayani, Fitraini, and Irma (2022) which states that students in the high self esteem group have very good mathematical communication skills, while students in the moderate self esteem group have mathematical communication abilities in the moderate category.

The Interaction between CMP and Self Esteem

Based on the calculation results of the two-way ANOVA test, the observed F-value ($F_{\text{Obs(AB)}}$) is 4.52, which is greater than the critical F-value ($F_{\alpha(\text{AB})}$) of 3.16. Therefore, we can conclude that the null hypothesis (H_{0AB}) is rejected, indicating that there is an interaction between the learning model and self esteem on students' mathematical communication skills. The interaction examined in this study is between the CMP learning model and direct learning model, and students' self esteem is categorized as high, moderate, and low.

Various factors influence students' mathematical communication skills, including learning models and self esteem. This study reveals an interaction between the learning model and self esteem in relation to students' mathematical communication skills. The CMP model facilitates the development of students' self esteem at all levels. By engaging with the CMP learning model, students can assess themselves positively, which boosts their self esteem and motivates them to learn mathematics, leading to improved mathematical communication.

In contrast, the direct learning model limits students with high, moderate, and low self esteem, as it revolves around teacher-centered instruction. Students with moderate and low self esteem become less curious and passive, lacking interaction in the classroom. Although students have the opportunity to ask questions and attempt exercises, it is insufficient to foster the development of mathematical communication skills. Consequently, students remain passive and refrain from asking questions. This poses challenges for teachers to gauge students' understanding of the material, hampering the proper development of mathematical communication skills across all self esteem levels.

Conversely, students who received the CMP learning model, irrespective of their self esteem levels (high, moderate, or low), exhibited superior mathematical communication skills compared to those who received the direct learning model. This aligns with the findings of Nufus (2017), which demonstrate the influence of learning interactions and school level on enhancing students' mathematical communication skills. Saragih and Anim (2018) similarly affirm the interaction between the learning model and students' initial mathematical abilities on their mathematical communication skills.

CONCLUSION

Based on the analysis and discussion of the impact of the CMP learning model on mathematical communication skills in relation to students' self esteem, the

following conclusions can be drawn: (1) Students using the CMP model exhibit better mathematical communication abilities compared to those using the direct learning model. (2) Students with high self esteem demonstrate superior mathematical communication skills compared to students with moderate self esteem, while students with moderate self esteem have better skills than those with low self esteem. Additionally, students with high self esteem exhibit better mathematical communication skills than students with low self esteem. (3) There is an interaction between the learning models and self esteem in influencing students' mathematical communication abilities. Students with high, moderate, and low self esteem who receive the CMP learning model display better mathematical communication skills than those with similar self esteem levels who receive the direct learning model.

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