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Case-Based Teaching Module to Improve Mathematics Reasoning and Mathematics Communication Skills of Grade 8 Students

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ARTICLE INFO	ABSTRACT
Published Online: 28 November 2025 **Corresponding Author:** Anggi Angriyani	This study aims to analyze the effect of the application of contextual teaching materials on the mathematical reasoning and communication skills of grade VIII students. The research method used was quasi-experimental with a nonequivalent control group design. The research subjects consisted of 45 students from one MTS which were divided into experimental classes and control classes. Instrument penelitian meliputi tes penalaran matematika dan komunikasi matematika yang diberikan pada pretest dan posttest. Data analysis used paired t-tests and MANCOVA to determine the difference in ability between groups after controlling for pretest scores. The results of the study show that the use of contextual teaching materials has a significant effect on improving students' mathematical reasoning and communication skills compared to conventional learning.

KEYWORDS: Case-Based Learning, Mathematical Communication, Mathematical Reasoning.

I. INTRODUCTION

According to KemendikbudRistek (2024) mathematics learning plays a role in developing students' logical, analytical, systematic, critical, and creative thinking skills, and through structured mental processes, students are guided to build a continuous stream of thought that leads to an understanding of mathematical material, including facts, concepts, principles, operations, relationships, and problem-solving that are formal and universal in nature. Mathematical reasoning skills and mathematical communication are two important skills that are the main focus in 21st-century mathematics learning. However, various studies show that both abilities are still low at various levels of education. The main cause is the use of teaching materials that are procedural, non-contextual, and do not support the development of high-level thinking skills. The formation of two abilities to students requires further action. One of these actions is a learning environment or learning process that needs to be designed properly in order to facilitate the formation of students' abilities (Barmby, et al., 2007; The Partnership For 21st Century Skills 2007; Mahmudi, et al., 2022 Conventional learning is still dominant so that students lack the opportunity to develop mathematical arguments and communication effectively. On the other hand, the contextual approach has been proven to be able to increase student engagement by associating mathematical concepts with real situations and can help students to be interactive and communicative with real life, in line with the results of the research that Solihat (2023) which states that the application of a contextual approach is very effective in improving students' mathematical communication skills. Research conducted by Chandra (2023) about developing contextual case-based learning tools Ternate specialties show that developed products improve mathematical literacy.

In addition, research by Suratno (2023) found that case-based learning in mathematics teaching has a positive impact on written mathematics communication skills. Referring to this condition, a study was conducted to see the impact of case-based teaching modules on improving mathematical reasoning and mathematical communication skills through a quasi-experimental design with MANCOVA analysis that controls students' initial abilities.

II. METHOD

This study used a quasi-experimental design of a nonequivalent control group. The experimental class uses conventional teaching modules, while the control class uses case-based teaching modules. A total of 45 grade VIII students participated in the research, consisting of 23 experimental class students and 22 control class students. The products are modules case-based teaching with the case-based learning syntax used in this study can be seen in the following Table.

Table I. Case-Based Learning Syntax

Teacher	Student
Presenting a case that has been prepared before learning Students read and understand the case presented	Students read and understand the cases presented
Asking students to analyze the presented cases Students analyze the cases	Students analyze cases individually with existing knowledge using concepts according to the material that has been studied
The teacher groups students into groups to ask the students to discuss	Students gather with their respective groups to gather information by discussing analyzing the case
The teacher facilitates or guides students during the process of analyzing the case	Students formulate solutions or answers to questions posed in the case
The teacher asks students to present the results of the case analysis from their group discussions	Each group presented the results of the case analysis

The research instruments are mathematical reasoning and mathematical communication tests. Each test instrument is validated through expert judgment and limited trials to ensure its validity and reliability. Data was collected through documentation, observation, and the provision of pretests and posttests in both groups. The data analysis technique was carried out quantitatively. Descriptive statistics are used to present an overview of pretest and posttest scores. Inferential statistics for the effectiveness of the case-based teaching module were developed using the paired t-test and MANCOVA test to analyze the difference in dependent variables simultaneously or simultaneously with the help of Jamovi software. Before being analyzed, the prerequisite assumptions of the hypothesis test are carried out, namely the normality test, the variance homogeneity test, the homogeneity of the variance-covariance matrix, there is a linear relationship between the dependent variable and the covariate variable, the assumption of regression homogeneity. The criteria for the MANCOVA test decision are met if the p-value < 0.05, meaning that by considering and paying attention to the pretest score, the case-based teaching module simultaneously has a significant effect on the dependent variables. Furthermore, to analyze the differences individually of the dependent variables (mathematical reasoning and mathematical communication) was carried out using the results of the test of between subject's effect. The criteria for this test decision are met if the p-value < 0.05, meaning that by considering and paying attention to the pretest score, the case-based teaching module has a significant effect on each dependent variable. The case-based teaching module is said to be effective if the MANCOVA test is met.

III. RESULT AND DISCUSS

Descriptive analysis was obtained during the field trial; it was seen that there was an increase in the average of the mathematical reasoning ability test from the average of the pretest of 18.65 to the posttest of 76.32 and the percentage of students who completed ≥ 70% after participating in learning activities using the developed case-based teaching module. Based on the effectiveness aspect, it can be said that the teaching modules developed meet the criteria of the teaching module with the effective category. The results of the descriptive analysis of the mathematical reasoning skills test can be seen in the following Table.

Table II. Descriptive Analysis of Mathematical Reasoning Ability Test

Data	Mathematical Reasoning Ability			
	Pretest		Posttest	
	Experiment	Control	Experiment	Control
Average	18,65	17,84	76,32	68,11
Standard Deviation	10,09	7,29	12,88	12,11
Varians	101,80	53,14	165,89	146,65
Median	16,66	16,66	78,12	66,66
Score Minimum	0	8,33	50	50
Score Maksimum	33,33	33,33	100	83,33
Range	33,33	25	50	33,33
Completion Percentage > KKM	0%	0%	77%	69%

Furthermore, the results of the descriptive analysis of the mathematical communication ability test can be seen in the following Table.

Table III. Descriptive Analysis of Mathematical Communication Ability Test

Data	Mathematical Communication Ability			
	Pretest		Posttest	
	Experiment	Control	Experiment	Control
Average	26,9	26,8	76,13	71,01
Standard Deviation	9,25	8,32	14,15	17,2
Varians	85,5	69,2	200,22	295,84

Median Score	25	25	75	75
Minimum Score	8,33	0	50	41,66
Maksimum	41,66	41,66	100	100
Range	33,33	41,66	50	58,34
Completion Percentage > KKM	0%	0%	72%	58%

The results of field trials in the classroom showed that there was an increase in the average mathematical communication ability test with a pretest of 26.9 and a posttest of 76.13 with a percentage of students completing ≥ 70% after participating in learning activities using the developed case-based teaching module. Based on the percentage of completeness in the number of students, it can be said that the teaching modules developed are effective. The effectiveness of the use of case-based teaching modules is seen from the pretest and posttest scores for improving mathematical reasoning and mathematical communication skills. The analysis was conducted inferentially using the paired t-test and MANCOVA to see if there were differences between the same sample and two different periods. Before that, a normality test was carried out to find out that the data obtained was distributed normally. Multivariate normality test with the help of Jamovi software. The results of the multivariate normality test can be seen in the following Table.

Table IV. Results of the Multivariate Normality Test

Data Type	**Hz**	**p-value**	**MVN**
Mathematical Reasoning and Mathematical Communication	0.813	0.141	Yes

The results of the multivariate normality test obtained a p-value > 0.05 which means that H_0. accepted and declared that the data is close to the normal distribution of multivariate, so that the conclusion is obtained that the data of mathematical reasoning and mathematical communication are normally distributed in a multivariate manner. The test results showed that the data was distributed normally, so it was followed by the paired sample t-test. This test was carried out with the help of Jamovi software. The results of the paired sample t-test in the field trial can be seen in the following Table.

Table V. Results of Paired Sample T-test

Variable	$t_{\frac{\alpha}{2}(n-1)}$	**p-value**	**Mean Difference**
Reasoning Mathematical	2.080	< 0,001	57.7
Communication Mathematical	2.080	< 0,001	49.2

Based on the results of the table above, it was obtained that the variable of mathematical reasoning ability obtained that the p-value was < 0.05, which is 0.001 which means H_0 rejected and it can be concluded that there is an increase in the average score of mathematical reasoning before and after using the developed case-based teaching module and for the variable of mathematical communication ability it is obtained that the p-value is < 0.05, which means H_0 rejected and it can be concluded that there was an increase in the average score of mathematical communication before and after using the developed case-based teaching module. The conclusion of this test results is that learning using the developed case-based teaching modules has a positive impact on improving mathematical reasoning and mathematical communication.

Furthermore, the variance homogeneity test carried out in this study uses the Levene's test and the covariance variance homogeneity test uses the Box's M test with the help of Jamovi software. This test was conducted to assess the distribution of data from both groups taken from populations that had the same variance. The results of the variance homogeneity test obtained a p-value of >0.05 which means that mathematical reasoning and mathematical communication data came from a population that had the same variance. The results of the covariance homogeneity test can be seen in the following Table.

Table VI. Results of the Covariance Homogeneity Test

Test	X^2	**p-value**
Box's M test	8.43	0,038

Based on the table above, it can be concluded that the covariance homogeneity test was not met (p-value < 0.05), meaning that the two dependent variables (reasoning posttest and communication posttest) did not have the same covariance matrix in each class. However, because the sample size between groups was relatively balanced, namely the experimental class of 22 students and the control class of 23 students. The analysis with MANCOVA continued using Pillai's Trace because this statistic is known to be more robust against the violation of (Tabachnick et al., 2019). The Box's M test does not test the assumption that the variance-covariance matrix of the residuals is similar across classes, but Levene's test assesses whether the residuals for a given dependent variable have the same variance between groups. Furthermore, the results of the MANCOVA test in the field trial can be seen in the following Table.

Table VII. Results of MANCOVA Test

Factor	Statistics (Pillai's Trace)	F	p-value
Group	0.170	4.41	0,018
Mathematical Reasoning Pretest	0.154	3.92	0.027
Mathematical Communication Pretest	0.186	4.92	0.012

Based on Table VII, the results of the Pillai's Trace test obtained a p-value of less than 0.05 which concluded that there was a significant difference in influence between groups on students' posttest scores simultaneously or together after controlling the students' pretest scores. Next, a test of between subject's effect will be carried out. The test results can be seen in the following Table.

Table VIII. Results of between subjects' effects

Faktor	Dependent	F	p-value
Group	Posttest Reasoning	7.04	0.011
	Posttest Communication	1.64	0.208
Mathematical Reasoning Pretest	Posttest Reasoning	218.5	< 0.001
	Posttest Communication	9.80	0.003
Mathematical Communication Pretest	Posttest Reasoning	2.75	0.105
	Posttest Communication	8.62	0.005

Based on Table VIII, the reasoning posttest gurp factor obtained a $p - \text{value} < 0.05$ which can be concluded that there is a significant difference between groups in the reasoning posttest score after controlling for the reasoning pretest score, meaning that the teaching module used has a significant effect on the mathematical reasoning ability of students. Meanwhile, in the communication posttest group factor, a p-value > 0.05 is obtained, which means that there is no difference between group to the communication posttest score significantly after controlling for the pretest score. Hasil MANCOVA menunjukkan perbedaan signifikan antara kedua kelompok terhadap gabungan kemampuan penalaran matematika dan komunikasi matematika. All paragraphs must be indented as well as justified, i.e. both left-justified and right-justified.

Based on the results of descriptive analysis and paired t-test, the case-based teaching module to improve mathematical reasoning and mathematical communication skills. The results of the analysis of mathematical reasoning and mathematical communication skills in the classroom showed a difference in the average posttest, which was 76.32 and 76.13. These results are supported by a paired sample t-test which shows that there is a difference in the average score of students' mathematical reasoning and mathematical communication after using the case-based teaching module, so that it can be concluded that the case-based teaching module meets the effectiveness aspect of mathematics reasoning and mathematical communication skills. This indicates that case-based teaching modules both contribute to the development of students' mathematical reasoning and mathematical communication skills. Sholihah & Retnawati (2019) explains that mathematical reasoning and communication is a thinking process that not only requires the ability to remember and understand concepts, so that the use of problems in learning is relevant to develop both abilities. Case-based learning is part of problem-based learning because it both places real problems as the starting point for learning to encourage active engagement, critical thinking, and problem-solving.

The results of the MANCOVA test after using the case-based teaching module in the experimental class showed a higher increase in the average value of mathematical reasoning and mathematical communication skills compared to the average score achieved in the control class, so it can be concluded that the case-based teaching module meets the effective aspects of mathematical reasoning and mathematical communication skills. This indicates that case-based teaching modules both contribute to the development of students' mathematical reasoning and mathematical communication skills, where during the learning process it is seen that students become more active in discussing and developing new ideas when facing problems or encountering cases related to the material being studied, because one of the stages of case-based learning is where the teacher groups students in groups and asks students to analyze and discuss the given case. These findings are strengthened by the research of Arianto et al. (2020), which states that case-based learning is able to encourage student activity. Other studies have also shown that this approach can improve learning activities and mathematical communication skills (Anwar & Rahmawati, 2024; Suratno et al., 2023).

Based on the results of the analysis of the effectiveness of mathematical reasoning skills before and after learning using products developed in the experimental class, it can be concluded that there is an increase in the average value of mathematical reasoning skills from pretest to posttest, thus it can be concluded that the teaching modules developed meet the criteria of effectiveness to improve mathematical reasoning skills. The analysis was also strengthened by the results of ANCOVA obtained that there was a difference in the influence of the pretest of mathematical reasoning ability on the posttest of mathematical reasoning ability significantly after controlling the pretest of mathematical reasoning ability, so that it can be concluded that case-based teaching modules are said to be effective because they can improve students' mathematical reasoning skills. This is in line with the opinion of Wati & Sunarti (2020) which states that case-based learning is able to improve reasoning skills. Research by Andini et al. (2023) also supports these results by showing that students who learn through a case-based approach obtain higher reasoning scores than students with conventional learning.

Based on the results of the analysis of the effectiveness of mathematical communication skills before and after learning using products developed in the experimental class, it can be concluded that there is an increase in the average value of mathematical communication skills from pretest to posttest, thus it can be concluded that the teaching modules developed meet the criteria of effectiveness to improve mathematical communication skills. Case-based learning is effective in improving mathematical communication skills but based on the results of the ANCOVA test analysis, it was found that there was no significant difference in mathematical communication skills between students who learned using case-based teaching modules and those who learned using problem-based teaching modules. This is inversely proportional to the average results of pretest and posttest scores on this ability which shows an improvement. The difference in results may be due to mathematical communication skills, which are skills that cannot be improved through just a few meetings because case-based learning uses complete case studies, so that students focus more on case analysis and solutions, not on elaborating arguments or delivering results in depth, as well as group dominance that causes some students to be confident to express ideas. In line with research by Linforth et al. (2023) explaining that time constraints on case-based learning cause students' attention more on analysis and completion than explicit communication exercises.

In line with the research of Dewi & Nurjanah (2022) suggests that case-based and problem-based learning can both improve mathematical connection ability, but do not produce significant differences between the two. Similarly, Fatmasuci (2017) it was found that problem-based learning tools are effective in improving mathematical communication because students are faced with real problems that encourage logical thinking, group investigation, questioning, answering, and clarifying concepts. Such group activity contributes directly to mathematical communication. In line with the results of Amni et al. (2024) it shows that problem-based modules are effective in improving mathematical communication because they involve the process of formulating problems, formulating hypotheses, and conveying ideas orally and in writing. Meanwhile, case-based learning also puts students in real situations that encourage group discussions, verbal and nonverbal interactions, so that they effectively train mathematical communication skills (Yoo & Park, 2015). Based on these aspects, it can be concluded that the case-based learning modules developed are able to improve mathematical reasoning and communication skills simultaneously.

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