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RELATIONSHIP ANALYSIS OF CRITICAL THINKING ABILITY WITH MATHEMATICAL MODELING ABILITY

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Abstract

Mathematical modeling is the heart of mathematical problem solving. In order for students to be able to solve problems well, they need to be able to think critically. This study aims to determine whether there is a positive and significant correlation between critical thinking skills and students' mathematical modeling abilities. This type of research is quantitative research with correlation analysis method. The sample used in this study were 35 students of class VIII.9 SMPN 10 Palembang. This research procedure consists of 3 stages, namely the preparation stage, the implementation stage, and the final stage. The data collection technique in this study used a written test. Based on the results of this study obtained the value of sig (0.021) < (0.05) with a correlation value of 0.388. Then it can be concluded that there is a positive and significant relationship between critical thinking skills and students' mathematical modeling abilities. The contribution of critical thinking skills to mathematical modeling abilities is 15.1%..

Keywords: Critical thinking ability, mathematical modeling abilitiy, SPLDV

Abstrak

Pemodelan matematika merupakan jantung dari pemecahan matematis. Agar siswa mampu memecahkan masalah dengan baik, maka mereka harus mampu berpikir secara kritis. Penelitian ini bertujuan untuk mengetahui apakah terdapat hubungan yang positif dan signifikan antara kemampuan berpikir kritis dengan kemampuan pemodelan matematika siswa. Jenis penelitian ini adalah penelitian kuantitatif dengan metode analisis korelasi. Sampel yang digunakan dalam penelitian ini sebanyak 35 orang siswa kelas VIII.9 SMPN 10 Palembang. Prosedur penelitian ini terdiri dari 3 tahap yaitu tahap persiapan, tahap pelaksanaan, dan tahap akhir. Teknik pengumpulan data dalam penelitian ini menggunakan tes tertulis. Berdasarkan hasil penelitian ini diperoleh nilai sig (0.021) < (0.05) dengan nilai korelasi sebesar 0.388. Sehingga dapat disimpulkan bahwa terdapat hubungan yang positif dan signifikan antara kemampuan berpikir kritis dan kemampuan pemodelan matematika siswa. Adapun kontribusi kemampuan berpikir kritis terhadap kemampuan pemodelan matematika adalah sebesar 15,1%.

***Kata kunci**: Kemampuan berpikir kritis, kemampuan pemodelan matematika, SPLDV*

INTRODUCTION

In order to solve everyday problems using mathematics, people must first convert the problem into a math problem. The mathematical representation of the problem is called a mathematical model. The process of making this model is known as modeling (Bliss and Libertini, 2016). If at school, students are required to solve everyday problems, they need to have this mathematical modeling ability.

Ability in mathematical modeling, demonstrating efforts to link real problems with mathematical concepts. By changing real problems into problems with mathematical concepts, making problems easy to understand

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and easy to find solutions (Permatasari, 2019). The components contained in mathematical modeling include (1) identifying problems, making assumptions and identifying variables, mathematics, analyzing and assessing solutions, interpreting, and implementing modeling (Bliss & Libertini, 2016; Rahmawati et al, 2018). In identifying problems aimed at generating questions in the real world. Furthermore, from the questions in the real world, "objects" that are considered important are selected and identification of the relationship to these "objects" is carried out. From here we get the initial question of the ideal version. Then this ideal initial question is translated in the form of a mathematical formula which is the mathematical model. From this model the solutions obtained are analyzed to ensure that the solutions are practical, reasonable and acceptable. The solutions obtained are interpreted to improve and expand the model. After that it is applied practically.

Efforts to model mathematical problems are influenced by several things, including student creativity (Siswono et al, 2022; Wulandary, Indaryanti, & Araiku, 2021), children's experience (Lestari, 2020), language skills (Sari, 2019), mathematical abilities and the art of modeling (Hartama, 2020). Creativity arises when students are faced with a problem that must be found a solution. In modeling this, according to Reys, et al (in Lestari, 2020) children's experiences associating physical objects with mathematical concepts also affect their ability to model mathematics. Furthermore, language skills are no less important in modeling because if the variable is misinterpreted, errors can occur in converting the mathematical modeling. Of course mathematical skills are needed in making mathematical models.

Mathematical problems can be converted into mathematical modeling. The process of converted can be seen in Figure 1.

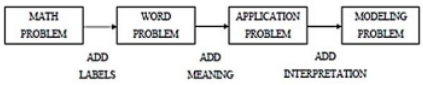

Figure 1. Changing math problems into mathematical modeling (GAIMME, 2019).

Starting from a mathematical problem that is labeled or named so that the problem becomes a problem that exists in the real world. This problem becomes a problem that can apply mathematical operations if it has been given meaning to a real problem. Furthermore, after interpreting the operations and variables contained in the applicable problem, a mathematical model can be developed. From this it is illustrated that in order to construct a mathematical model, it is necessary to have mathematical ability or mastery of mathematical concepts.

One of the new approaches in teaching mathematics is teaching using mathematical modeling (Hartono, 2017). According to Agus (2021) mathematical modeling can be considered as an abstraction or simplification of problems in real-world situations (complex) into mathematical forms, thus turning real-world problems into mathematical problems. The mathematical problem is then solved using known techniques to obtain a mathematical solution.

Mathematical modeling is a series of cycles of solving mathematical problems (Suwanto, et al: 2017). Modeling moves from a simplified real problem to a mathematical model. After

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becoming a mathematical model, mathematical operations are carried out to obtain a mathematical solution. From mathematical solutions interpreted in the real world to solving mathematical problems.

In the modeling approach, students will be accustomed to transforming real world problems into mathematical models or in other words students can model problems. With modeling, students will be trained to understand (identify) problems, relate underlying mathematical concepts to modeling, connect mathematical ideas so that a form of mathematical model is found, to then complete the mathematical model found. In the process of mathematical modeling using the language of mathematics to measure and analyze the real world, using mathematics to explore and develop understanding of real world problems, as well as carrying out an interactive problem-solving process where mathematics is used to investigate and deepen an understanding (Kurniadi, et al, 2020).

Mathematical modeling is at the heart of mathematical problem solving. In modeling learning, students are required to formulate problems, formulate appropriate mathematical models to get solutions, this can be supported by critical thinking skills to solve existing problems. Critical thinking involves reasoning and reflective thinking that focuses on determining what to believe and what to do (Ennis, 1998). This is the importance of critical thinking skills (Kemendikbud, 2017). Critical thinking skills begin with students' involvement with a problem. They carry out investigations whose purpose is to explore situations, phenomena, questions, or problems so as to reach a conclusion (Kurfiss, 1988). They are able to identify questions that are worth solving, and are able to provide evidence to support an argument (Pithers & Soden, 2000). Critical thinking requires effort, a sense of concern about accuracy, willingness, and an attitude of not giving up easily when faced with difficult tasks and planning problem solving strategies from various sources (Agus, 2021; Sukmawati, 2018). Critical thinking requires strenuous effort to examine every assumptive belief or knowledge based on its supporting evidence and the resulting further conclusions (Mahardiningrum & Ratu, 2018). This shows that critical thinking can be defined as a person's thinking process that begins with the desire to solve a problem, through testing various alternatives and choosing the most appropriate and most logical solution.

Critical thinking ability and problem solving skills are closely related to one another (Rahman, 2019). They require a person to be able to: 1) reason efficiently, 2) ask clear questions, 3) evaluate alternatives with multiple perspectives, and 4) evaluate critically the choices and procedures applied (Harlen & Symington, 1987). In solving a problem, one must be able to understand the given problem and then make a plan before executing it. One form of the plan in question is a mathematical model based on a given problem. That is, the ability to model mathematically requires the ability to think critically, so that there is a relationship between mathematical modeling ability and critical thinking ability.

Several studies on critical thinking skills relate it to problem solving (Kim & Ryu, 2022; Hursen, 2021; Junsay, 2016), learning

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motivation (Valenzuela, Nieto, & Saiz, 2011; Hu, Jia, Plucker, & Shan, 2016; Riyanto , & Mariani, 2019), self-efficacy (Riyanto & Mariani, 2019; Dehghani, Pakmehr, & Malekzadeh, 2011), as well as mathematical communication (Junsay, 2016; Nasrulloh, & Umardiyah, 2021). However, not many references have been found that specifically link critical thinking skills and mathematical modeling abilities. Therefore, this article aims to discuss the analysis of the relationship between critical thinking skills and mathematical modeling abilities.

METHOD

The type of research used in this research is quantitative research (Sugiyono, 2015), which aims to show the relationship between critical thinking skills and mathematical modeling ability. Critical thinking ability is the ability to think logically and utilize the skills that are already owned to make decisions or conclusions in solving a problem properly accompanied by evidence and reasons. The indicators used in critical thinking skills are giving simple explanations; provide further explanation; determine strategies and techniques; and concluded. The following indicators are used in mathematical modeling abilities, namely constructing/understanding problems; simplification/ building structures; mathematize; work mathematically; interpret. The research was conducted at SMP Negeri 10 Palembang in the even semester of the 2021/2022 school year.

The population in this study were class VIII students of SMP Negeri 10 Palembang for the 2021/2022 academic year. Selection of the sample in this study using a sampling technique *Cluster Random Sampling*. The sample of this study was students of class VIII.9, SMP Negeri 10 Palembang, totaling 35 people. They were given material on the System of Two Variable Linear Equations (SPLDV).

The instrument used in this study was in the form of 4 test items. The test items were used to measure students' critical thinking skills and mathematical modeling abilities which consisted of 2 critical thinking skills questions and 2 mathematical modeling ability questions.

Student test results were analyzed using regression and correlation techniques. In this study, the direction, strength, contribution and significance of the correlation between the two variables will be seen. The direction, strength, and contribution of the correlation were seen using the Pearson product moment correlation test. Data analysis used SPSS 26. The categories of correlation strength can be seen in Table 1.

TablE 1. Correlation coefficient (Dancey, Reidy, 2007).

Range	Category
0	No Corellation
0,001 – 0,399	Weak
0,400 – 0,699	Moderate
0,700 – 0,999	Strong
1	Perfect

RESULTS

The research activity was carried out in class VIII.9 of SMP Negeri 10 Palembang on Wednesday 9 March 2022. The research activity was carried out in two sessions, namely at 08.40-10.00 WIB (Western Indonesian Time) and 12.45-14.00 WIB. This is based on the Minister of Education and Culture circular letter No. 2 of 2022 concerning face-to-face learning which began to be

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implemented at Palembang 10 Public Middle School with a student population of 50% of the classroom capacity. So that in one class there are 2 meetings on 1 subject on the same day.

The researcher only gave the instrument questions that students had to work on in the form of 4 essay questions which consisted of 2 questions on critical thinking skills and 2 questions on mathematical modeling abilities during the research. Research activities were carried out in two sessions, the first session starting at 08.40-10.00 WIB and the second session at 12.45-14.00 WIB. The researcher enters the class and prepares the students, the students then pray, then the researcher takes the students' names one by one. The researcher reminded again about the material contained in the question instrument and then distributed the question sheets to each student.

Figure 2 shows the results of students' answers that have been scored based on indicators of critical thinking skills and mathematical modeling abilities.

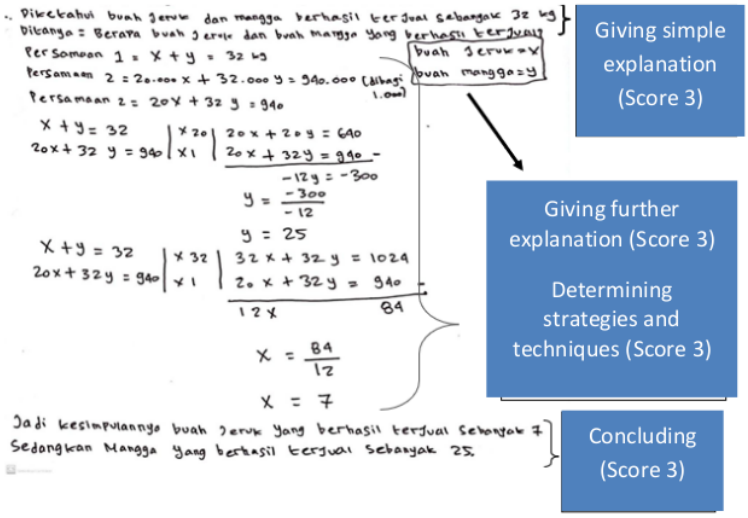

Figure 2. Student answers with code S-1 about critical thinking skills from question number 1. The results of S-1 work are scored based on critical thinking indicators (indicators are in the boxes) and the numbers indicate the scores obtained.

Based on Figure 2, it can be seen that S-1 students are able to solve problems with indicators, provide simple explanations by writing down the results of the analysis of what questions are known and asked in full (score 3), provide appropriate further explanations by making a mathematical model (score 3), determine strategies and techniques by connecting the information provided correctly (score 3), and concluding by writing the conclusions of the answers correctly (score 3).

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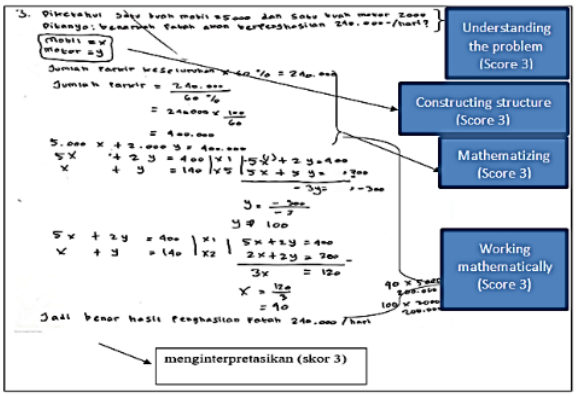

Figure 3. S-1 code student answers about critical thinking ability question number 3. Answers are assessed based on critical thinking indicators (critical thinking indicators are located in the plot), the numbers indicate the scores obtained.

Based on Figure 3 it can be seen that the students' answers to the indicator of understanding the students' problems were able to identify the problems given by writing down what was known and asked from the questions. On the indicators of building structures students are able to determine variables by determining the variables from the questions, on the mathematization indicators students can design mathematical models based on predetermined variables, on the indicators of working mathematically students are able to complete their answers correctly, also on the indicators interpret students are able to write conclusions from answers into real-world contexts correctly according to the questions given.

The maximum score for each indicator of critical thinking ability and mathematical modeling ability is 3.

$$\text{Nilai siswa} = \frac{Total\ Score}{max.score} \times 100$$

The following list of student test scores can be seen in Table 2.

Table 2. List of student test scores

No	Students code	Grade	
		Critical Thinking Ability	Mathematical Modeling Ability
1	S-1	Working mathematically (Score 3)	87
2	S-2		33
3	S-3		47
4	S-4		37
5	S-5	50	20
6	S-6	67	33
7	S-7	83	33
8	S-8	71	87
9	S-9	71	33
10	S-10	33	73
11	S-11	33	47
12	S-12	71	70
13	S-13	58	30
14	S-14	88	43
15	S-15	0	0
16	S-16	75	20
17	S-17	75	10
18	S-18	54	10
19	S-19	50	10
20	S-20	54	43
21	S-21	58	47
22	S-22	0	0
23	S-23	87	63
24	S-24	13	57
25	S-25	46	63
26	S-26	83	63
27	S-27	33	33
28	S-28	33	33
29	S-29	71	43

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No	Students code	Grade	
		Critical Thinking Ability	Mathematical Modeling Ability
30	S-30	46	20
31	S-31	58	20
32	S-32	58	20
33	S-33	54	57
34	S-34	83	73
35	S-35	33	40

Results of Data Analysis

Description of Prerequisite Test Analysis Results

The results of the normality and linearity tests can be seen in Table 3 and Table 4.

Table 3. Normality test results

Kolmogorov-Smirnov[a]			Shapiro-Wilk		
Statistic	Df	Sig.	Statistic	df	Sig.
.104	35	.200*	.968	35	.396

The normality test uses SPSS 26 software by looking at the comparison of significant values and α values, the α value used is 0.05. If the significant value > α then the result data is normally distributed but if the significant value < α then the result data is not normally distributed. In this normality test the researchers used the results from Shapiro-Wilk because the number of samples in this study was <50.

Based on the table of data from the normality test results, it can be seen that the data on critical thinking skills and mathematical modeling abilities are normally distributed because their significance value is more than 0.05.

Then a linearity test was carried out on both data. Table 4 produces the results of the linearity test.

Table 4. Linearity Test Results

ANOVA Table							
			Sum of Squares	Df	Mean Square	F	Sig.
Mathematical Modeling Ability * Critical Thinking Ability	Between Groups	(Combined)	10572.226	13	813.248	2.185	.054
		Linearity	1762.679	1	1762.679	4.737	.041
		Deviation from Linearity	8809.547	12	734.129	1.973	. 083
	Within Groups		7814.517	21	372.120		
	Total		18386.743	34			

Based on Table 4, it can be seen that the deviation from linearity value with sig. of 0.083 while the value of α used is 0.05. If seen from Table 3, the deviation from linearity value is 0.083> 0.05 so it can be concluded that critical thinking skills and mathematical modeling abilities have a linear relationship.

Description of Hypothesis Test Analysis Results

The results of the analysis of hypothesis testing can be seen in Tables 5, 6, 7 and 8.

Table 5. T test results

Coefficients[a]					
	Unstandardized Coefficients		Standardized Coefficients		
Model	B	Std. Error	Beta	t	Sig.
(Constant)	18.426	9.619		1.916	.064
Critical Thinking Ability	.383	.158	.388	2.418	.021

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Based on Table 5 it can be seen that a significant value of 0.021 is obtained. Sig value (0.021) < (0.05) it can be concluded that there is a significant relationship between critical thinking skills and mathematical modeling abilities. From table 5, the regression equation y = 0.383 x + 18.426 is obtained.

Table 6. Lack of fit tests

Source	Sum of Squares	df	Mean Square	F	Sig.
Lack of Fit	8461,518	12	705,126	2,132	,062
Pure Error	6946,267	21	330,775		

Dependent Variable: Modeling

Table 6 shows no evidence of incompatibility of the above model (p=0.062). Furthermore, there is no visible pattern in the scatter diagram between standardized predicted values and standardized residuals. This shows that there is no violation of the assumptions of the regression model. The correlation coefficient is 0.388 with a lower limit and an upper limit of 95% confidence intervals 0.061 and 0.705 respectively indicating that there is a positive correlation between critical thinking ability and modeling ability. That is, the higher the critical thinking ability, the higher the modeling ability. Critical thinking ability has a contribution of 15.1% to the variation in modeling ability. This means that there are other variables that contribute to variations in modeling ability.

After obtaining a significant relationship between critical thinking and mathematical modeling ability, a correlation test was carried out between the two. The results of the correlation test are listed in Table 7.

Table 7. *Product moment pearson correlation test results*

		Critical Thinking Ability	Mathematical Modeling Ability
Critical Thinking Ability	Pearson Correlation	1	.388*
	Sig. (2-tailed)		.021
	N	35	35
Mathematical Modeling Ability	Pearson Correlation	.388*	1
	Sig. (2-tailed)	.021	
	N	35	35

The value of the correlation coefficient of critical thinking skills and mathematical modeling abilities obtained from the data is equal to 0.388. Based on the correlation coefficient category in Table 1, the correlation obtained is positive and has a weak category. Positive means that it has a unidirectional correlation, that is, if the value of critical thinking ability is low, then the value of mathematical modeling ability is also low. Vice versa if the value of students' critical thinking skills is high, the value of students' mathematical modeling abilities is also high.

Based on Table 7, the sig value obtained is 0.021 and the α value used is 0.05, so 0.021 < 0.05. This means that the data correlation is significant, so it is

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concluded that critical thinking skills and mathematical modeling abilities have a correlation.

This can be seen in table 1 which lists student scores that students with S-1 and S-8 codes when the value of critical thinking skills is high, the value of mathematical modeling ability is also high. Likewise for students with codes S-27 and S-35 that the value of critical thinking skills is low and the value of mathematical modeling skills is also low.

So the ability to think critically has a significant positive correlation with the ability to model mathematics. This means that in doing mathematical modeling, critical thinking skills are needed. Furthermore, it is necessary to do a determinant test to find out how much critical thinking ability is in doing mathematical modeling. The results are listed in Table 8.

Table 8. Determinant test result

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.388[a]	.151	.125	21.608

The determinant coefficient test was carried out using SPSS 26 with the results shown in Table 8, namely the r square value of 0.151. In addition to knowing the coefficient of determinant, Table 8 is used to find out the percentage of the relationship between variable X and variable Y. The percentage relationship is obtained by changing the value of r square into the form of a percentage, which is 15.1%. Based on the test results of the determinant coefficient, it can be concluded that the ability to think critically contributes 15.1% to the ability of mathematical modeling.

DISCUSSION

Based on the results of the t test, the sig value (0.021) < (0.05) is obtained and the product moment correlation coefficient is 0.388 meaning that there is a significant relationship between critical thinking skills and mathematical modeling abilities. This means that in doing mathematical modeling, critical thinking skills are needed. The coefficient of determination of 15.1% indicates that the ability to think critically contributes 15.1% to the variation in modeling ability.

Mathematical modeling is the process of simplifying real problems into realistic models, and continuing to become mathematical models (Suwanto, et al; 2017). In this process, real problems are transformed into realistic problems. In turning it into a realistic problem, mathematical concepts and facts are needed. Mathematical facts in the form of mathematical symbols. Translating into a realistic problem requires deep thinking, reasoning on mathematical concepts that are believed to be correct to form mathematical models. Deep thinking with reasoning is what is meant by critical thinking (Hidayat, 2019). This process requires the ability to think critically to ensure that the mathematical concepts used are correct.

In addition, modeling real problems to become realistic models and then to become mathematical models requires effort and willingness to materialize mathematical modeling. Doing modeling is an activity of translating the real world into abstract mathematics. Mathematical abstractness requires accuracy in determining a

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mathematical model that fits the real problem. Therefore it takes a persistent will and attitude in overcoming problem solving. This is in line with critical thinking expressed by Sukmawati (2018).

Based on the results of previous research that influences mathematical modeling abilities include language skills (Sari, 2019), student creativity (Siswono et al, 2022; Wulandary, Indaryanti, & Araiku, 2021), children's experience (Lestari, 2020), language skills (Sari , 2019), mathematical abilities and the art of modeling (Hartama, 2020). With this research it was found that in addition to the abilities that have been presented earlier, the ability to think critically also influences mathematical modeling. Critical thinking can solve problems in life both in society and individually (Wasqita et all, 2022).

CONCLUSION AND SUGGESTION

Data analysis showed that critical thinking had a significant positive relationship (r=0.338) with the mathematical modeling abilities of class VIII.9 students of SMP Negeri 10 Palembang (p=0.021), even though the contribution was only 15.1%. That is, the higher the students' critical thinking skills, the higher their mathematical modeling abilities.

As for suggestions that can be made for further research, namely the results of this study can be used as reference material to analyze other mathematical abilities that affect mathematical modeling abilities.

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