THE EFFECT OF STUDENTS' MATHEMATICAL DISPOSITION ON MATHEMATICAL CRITICAL THINKING ABILITY OF ELEMENTARY SCHOOL STUDENTS

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Abstract:

This study investigates the effect of students' mathematical dispositions on elementary school students' mathematical critical thinking abilities. The existing problems are related to low critical thinking skills and poor mathematical disposition of students, including low curiosity, low ability to ask questions during the mathematics learning, and poor ability to provide logical reasons for communicating ideas. This research was quasi-experimental, where the participants in this study amounted to 49 5th-grade students in two integrated Islamic elementary schools in Cirebon City, Indonesia. Data was collected through a questionnaire of students' mathematical disposition and a test of mathematical critical thinking ability. The data analysis employed descriptive statistical analysis and simple regression analysis. The research found that the students' mathematical disposition significantly affects elementary school students' mathematical critical thinking ability. The significance value is significant (sig. 0.000 <0.05) with a correlation coefficient of 0.597. The results also reveal that students with a high level of mathematical disposition perform better in mathematical critical thinking ability than students with medium and low mathematical dispositions. So, it can be concluded that the mathematical disposition influences students' mathematical critical thinking abilities.

Abstrak:

Penelitian ini bertujuan untuk menginvestigasi pengaruh disposisi matematis siswa terhadap kemampuan berpikir kritis matematis siswa sekolah dasar. Dengan adanya permasalahan terkait rendahnya kemampuan berpikir kritis dan disposisi matematis siswa yang kurang baik, seperti rasa ingin tahu yang rendah, kemampuan bertanya ketika proses belajar matematika yang rendah serta kemampuan memberikan alasan yang logis dalam mengkomunikasikan ide-ide yang kurang. Penelitian ini merupakan penelitian kuasi eksperimen. Partisipan dalam penelitian ini berjumlah 49 siswa kelas 5 di 2 (dua) sekolah dasar Islam terpadu di Kota Cirebon, Indonesia. Data dikumpulkan melalui angket disposisi matematis dan tes kemampuan berpikir kritis matematis. Sementara itu, data hasil penelitian dianalisis melalui analisis statistik deskriptif dan analisis regresi sederhana. Hasil penelitian menunjukkan bahwa disposisi matematis siswa berpengaruh signifikan terhadap kemampuan berpikir kritis matematis siswa sekolah dasar. Nilai signifikansinya sebesar sig. 0.000 < 0.05 dengan koefisien korelasi 0.597. Hasil penelitian juga mengungkapkan bahwa siswa yang memiliki level disposisi matematis tinggi, kemampuan berpikir kritis matematisnya lebih baik dibandingkan dengan siswa yang memiliki level disposisi matematis sedang dan rendah. Sehingga dapat disimpulkan bahwa disposisi matematis berpengaruh terhadap kemampuan berpikir kritis matematis siswa.

Keywords:
Mathematical Disposition, Mathematical Critical Thinking Ability,
Elementary School Students

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INTRODUCTION

Nowadays, there is a prevailing focus on fostering mathematical critical thinking abilities within the global mathematics education curriculum. This emphasis stems from the belief that enhancing critical thinking skills has the possibility of increasing students' overall mathematical performance. The development of mathematical critical thinking skills has the potential to foster independent problem-solving abilities among students, both within the educational setting and in their daily lives (Firdaus, Kailani, Bakar, & Bakry, 2015). Furthermore, a crucial talent that students in the era of Industry 4.0 must possess in order to navigate their daily lives and effectively address the demands of this period is the ability to engage in critical mathematical reasoning (Arifuddin, 2019; Arifuddin, 2020; Biber, Tuna, & Incikabi, 2013).

Consistent with this viewpoint, Kurniati, Kusumah, & Subandar (2015) asserted that the instruction of mathematics should commence with primary education, as it serves as the fundamental basis for cultivating students' aptitude for critical thinking within the realm of mathematics at subsequent educational stages. Cahyana, Kadir, & Gherardini (2017) suggest that critical thinking is a cognitive process characterized by its transparency and purposefulness, employed for problem-solving, decision-making, assumption analysis, and scientific inquiry. Consistent with the assertion made by Cahyana, Kadir, & Gherardini (2017); Lipman (2014) similarly posited that critical thinking is a systematic cognitive process that contributes to decision-making, problem-solving, and the acquisition of new knowledge.

Critical thinking encompasses a range of distinct processes that are employed in the examination of an issue, the gathering of data, the assessment of data, and the amalgamation of information in order to arrive at conclusive determination (Zulmaulida, Wahyudin, & Dahlan, 2018). Setyawati (2013) similarly posited that individuals who engage in critical thinking possess particular attributes that are: the ability to approach problem-solving with a clear objective, the capacity to analyze, synthesize, and structure ideas grounded in factual evidence or available information, and the aptitude to arrive at sound conclusions supported by valid arguments. According to Zetriuslita, Eahyudi, & Jarnawi (2017), students possess the capacity to discern the crucial aspects of a situation and employ deliberate strategies and judgments in order to address their challenges effectively. Al-Mubaid (2014); Sholehawati & Wahyudin (2019) have discussed mathematical critical thinking as a higher-order thinking skill organization.

Several studies show that students' critical thinking skills still need to be improved. The results of research by Widiantari, Suarjana, & Kusmariyatni (2016) revealed that, the critical thinking abilities of class IV students were still relatively low, namely 70%. If we look at the critical thinking ability indicators, the indicator for analyzing questions is in the high category, namely 82.99%. Meanwhile, for identifying the assumption was very low, namely 0%. Apart from that, the students' mathematical disposition is also poor, such as lack of curiosity, a low ability to ask questions during the mathematics learning process, and a poor ability to provide logical reasons for communicating ideas.

The capacity for mathematical critical thinking is strongly associated with the mathematical disposition of students. According to the (National Council of Teachers of Mathematics (1988), a mathematical disposition deals with a cognitive and behavioral inclination towards mathematics, characterized by a positive mindset and a liking for the subject. This inclination is seen in the level of engagement and self-assurance that students exhibit towards gaining mathematical knowledge. According to Wardani (2009), in alignment with the National Council of Teachers of Mathematics (1988), students' mathematical dispositions encompass various attributes such as self-assurance, inquisitiveness, tenacity, eagerness for knowledge acquisition, resilience in tackling challenges, adaptability, openness to collaboration, and reflective engagement in the process of learning mathematics.

Previous studies related to mathematical disposition have been performed. Cruz, Wilson, & Wang (2019) conducted a study to investigate the correlation between mathematical disposition and future teacher self-efficacy in teaching mathematics. The investigation showed that the mathematical inclination and self-efficacy of prospective educators have a significant impact on their instructional practices and behaviors when teaching mathematics in an educational setting. The study conducted by Sa'diyah, Sa'dijah, & Handayani (2019) examined the process by which students developed their mathematical dispositions in order to tackle both contextual and abstract mathematical issues effectively. The findings of the research suggested that a method by which pupils develop their mathematical disposition is by engaging in the process of solving conceptual mathematical problems. In a study by Cruz (2017) that focus on examining the mathematical disposition and self-efficacy of potential teachers in teaching mathematics. The findings of his research implied a highly substantial correlation between mathematical propensity and self-efficacy among prospective mathematics educators. In his study, Kusmaryono, Suyitno, & Dwijanto (2019) examined the development of mathematical disposition in relation to the acquisition of mathematical power or strength. The findings of his research showed a notable correlation between individuals' mathematical propensity and their proficiency in mathematical problem-solving skills. Hence, it is imperative for educators to enhance the mental disposition of students by carefully choosing instructional approaches that foster the development of cognitive and conative abilities in tandem. In their study, Joko AB, Margono, & Rahayu (2019) on the mathematical disposition and its relationship to logical thinking abilities found a favorable correlation between mathematical propensity and logical thinking

skills. In contrast to previous studies, this research focused on the influence of mathematical dispositions on students' mathematical critical thinking skills. This study examined the effect of a mathematical disposition on elementary school students' mathematical critical thinking skills.

RESEARCH METHOD

This study employs a quasi-experimental design to examine the impact of specific interventions on various subjects within a controlled experimental setting. The study involved 49 fifth-grade students from two integrated Islamic elementary schools in Cirebon City, West Java. The study sample comprised 23 male students and 26 female students, whose ages ranged from 11 to 13 years on average. In this study, the initial step was the distribution of a mathematical disposition questionnaire to the students. The mathematical disposition questionnaire was administrated prior to students engaging in the instructional activities pertaining to the mathematical concepts of cube and block volumes. Following several classroom sessions dedicated to exploring the concepts of the volume of cubes and blocks, students are given a test to assess their proficiency in mathematical critical thinking.

The present study employed two research instruments, namely the mathematical inclination questionnaire and the mathematical critical thinking ability test. The researchers employed the mathematical disposition questionnaire as a tool for assessing the mathematical disposition of the students. The questionnaire had 25 statements related to various areas of mathematical disposition as outlined by the National Council of Teachers of Mathematics (1988). The factors encompassed in mathematical disposition include (1) a sense of self-assurance in tackling mathematical problems, effectively conveying ideas, and providing justifications; (2) adaptability in exploring mathematical concepts and employing various alternative approaches to problem-solving; resolute commitment to completing mathematical tasks; genuine interest, inquisitiveness, and proficiency in mathematics; (3) inclination to introspect on one's cognitive processes and performance; evaluate the practical application of mathematics in other disciplines and everyday situations; and (4) recognition of the significance of mathematics in culture and its inherent worth, encompassing mathematics as a tool and mathematics as a language National Council of Teachers of Mathematics (NCTM, 1988). The mathematical disposition questionnaire employed in this study was a Likert scale format with four response options: always, often, sometimes, and never. The subsequent tool pertains to an assessment of mathematical critical thinking abilities. This assessment was used to evaluate students' mathematical critical thinking abilities after their participation in a mathematics curriculum focused on the concept of of cube and block volumes. The assessment comprises four descriptive inquiries related to the measure of volume for cube and block within the context of a fifth-grade classroom. The subject of this examination refers to the assessment of critical mathematical thinking indicators, according to Brookhart (2010). These indicators cover the abilities to classify, provide reasons, analyze, and draw conclusions. The assessment is subsequently evaluated based

on the provided scoring standards, which assign a numerical value of 0.1 and 2 for each indicator. A score of 0 suggests that the student either fails to provide a response or provides an incorrect one. A response with a score of 1 means partial completion or a few errors, whereas a score of 2 signifies a correct and comprehensive answer by students.

Before being used to collect research data, the instruments were tested for empirical validity. Empirical validity is applied to test the validity of the instrument statistically. The statistical analysis used is correlation analysis, namely looking for a relationship between test scores and specific criteria used as benchmarks. Testing the validity of the mathematical disposition questionnaire was conducted by correlating each score obtained on each item statement with the total score. While testing, the validity of the test instrument for mathematical critical thinking skills is determined by correlating each score got by students on each item on the test of mathematical critical thinking skills with a total score.

Product moment-person correlation was used to assess the validation of the mathematical disposition questionnaire instrument. This involves examining the relationship between the scores obtained on each statement item and the overall total score. Table 1 displays the outcomes of the validity assessment conducted on the mathematical disposition questionnaire instrument.

Table 1. Results of the Mathematical Disposition Questionnaire Validity Test

Number of items	**Average of r_{xy}**	**r table**	**Criteria**
25	0.624	0.388	Valid

Based on the results of the validity test on the mathematical disposition questionnaire instrument in Table 1, it was found that the average value of rxy for each item was > r table, namely 0.624 > 0.388. Therefore, it can be concluded that the developed mathematical disposition questionnaire meets valid criteria and can be used to collect research data.

Next is testing the validity of the items on the mathematical critical thinking ability test. Testing the validity of these items is done by correlating each score on each item with the total score. Validity testing was carried out using the Pearson Product-Moment correlation. To test the validity of the things, hypothesis H0 is proposed: there is no positive correlation between the scores of each item and the total score. Meanwhile, in H1, there is a positive correlation between the score of each item and the total score. If the test criterion is r count (rxy) ≥ r table at a significance level of $\alpha = 5\%$, then the null hypothesis is rejected. At the significance level $\alpha = 5\%$ and n = 26, it is obtained that r table = 0.388.

The results of testing the validity of the mathematical critical thinking ability test instrument are presented in Table 2 below.

Table 2. Results of the Mathematical Critical Thinking Ability Instrument for the Validity Test

Number of items	Validity	
	r_{xy}	criteria
1	0,778	Valid
2	0,880	Valid
3	0,736	Valid
4	0,832	Valid

The validity test conducted on the mathematical critical thinking ability test instrument, as shown in Table 2, reveals that the rxy value for each item surpasses the established threshold of rtable = 0.388. Hence, it can be assumed that the mathematical critical thinking assessment tool meets the qualifications of validity and can be applied to gather empirical data in research studies.

After the research data collection process is completed, the next step is to process and analyze the data. Research data was analyzed using descriptive statistical data analysis techniques, correlation tests, and linear regression tests. Descriptive statistical tests were conducted to measure the mean, standard deviation, and normality. Data on students' mathematical dispositions were analyzed using standard criteria for classifying students' mathematical disposition levels. The standard criteria for grouping students' mathematical disposition levels are shown in Table 3 below.

Table 3. Criteria for Grouping Students' Mathematical Disposition Levels

Score range	Criteria
76-100	High-Level Mathematical Disposition
51-75	Medium Level Mathematical Disposition
25-50	Low-Level Mathematical Disposition

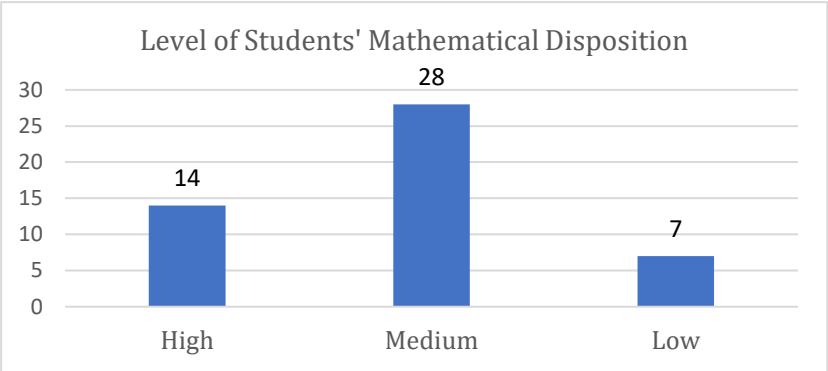
Subsequently, the data pertaining to the outcomes of assessments measuring mathematical critical thinking abilities were subjected to analysis employing the Pearson correlation test. The Pearson correlation test was applied to assess the association between students' mathematical disposition and their mathematical critical thinking abilities. The linear regression analysis method is employed to ascertain the potential of students' mathematical inclinations in predicting their mathematical critical thinking abilities. In this study, a post hoc analysis was performed to examine the mean disparities in students' mathematical critical thinking skills, accounting for the varying levels of students' mathematical inclinations.

RESULTS AND DISCUSSION

The Results of Descriptive Analysis

A descriptive analysis is conducted on the outcomes of the mathematical disposition questionnaire administered to students, as well as their exam for mathematical critical thinking abilities. The initial step involves doing an analysis of the questionnaire data pertaining to the mathematical disposition of the students. The

analysis involved categorizing their mathematical disposition into three distinct groups: those who are with a high level, students with a moderate level, and students with a low level. The findings of the descriptive analysis referring to the mathematical dispositions of students are displayed in Graph 1, as shown below.



Graph 1. The Level of Students' Mathematical Disposition

Graph 1 shows that most students have a moderate level of mathematical disposition, whereas 28 students have a moderate level of mathematical disposition. Meanwhile, 14 students had a high level of mathematical disposition, and seven had a low level.

Table 4. Descriptive Statistics of Mathematical Disposition and Students' Mathematical Critical Thinking Ability

Aspects that are measured	Mean	Maximum	Minimum	Std. Deviation	N
Students' mathematical disposition	67.47	86	40	10,504	49
Students' Mathematical Critical Thinking Ability	74,96	100	38	13,597	49

Table 4 shows that students' mathematical disposition scores have the lowest score of 40 and the highest score of 86, with an average score of 67.47 and a standard deviation of 10.504. Meanwhile, students' mathematical critical thinking ability scores had the lowest score of 38 and the highest score of 100, with an average score of 74.96 and a standard deviation of 13,597.

Correlation between Mathematical Disposition and Mathematical Critical Thinking Ability

A regression test was carried out to determine the correlation or relationship between mathematical disposition and students' mathematical critical thinking ability. This hypothesis test measured the correlation and regression coefficients between mathematical disposition and students' critical thinking ability. The data being compared are the students' mathematical disposition questionnaire score data and the post-test

score data for the mathematical critical thinking abilities of the entire research sample. Assuming that the two data are typically distributed and homogeneous, the hypothesis is tested using a simple linear regression test assisted by SPSS version 22. The simple linear regression analysis results are presented in Table 5 below.

Table 5. Simple Linear Regression Test Results

Coefficients [a]						
Model		**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig.**
		B	**Std. Error**	**Beta**		
1	(Constant)	22.818	10.340		2.207	.032
	math_disposition	.773	.151	.597	5.102	.000
a. Dependent Variable: math_critical_thinking_score						

The findings of the basic linear regression analysis presented in Table 5 indicate that the significance level is below the threshold of 0.05 (sig. 0.000 <0.05), suggesting a statistically significant relationship. Furthermore, the correlation coefficient of 0.597 indicating a moderate positive correlation between the variables. Due to the obtained significance value being below the threshold of 0.05, the null hypothesis (H0) is rejected in favor of the alternative hypothesis (Ha). This implies that there is a positive correlation or a significant effect between students' mathematical inclinations and their mathematical critical thinking abilities. The correlation coefficient between mathematical disposition and students' mathematical critical thinking abilities is 0.597.

According to the findings presented in Table 5, the regression equation Y = 0.773X + 22.818 is derived. This equation indicates that for every unit increase in variable X, there is a corresponding increase of 0.773 in variable Y. Therefore, it can be inferred that there exists a positive link or considerable impact on students' mathematical disposition and their mathematical critical thinking abilities.

This observation demonstrates the impact of pupils' mathematical dispositions on their critical thinking skills. The correlation between a student's level of mathematical disposition and their critical thinking skills is evident, as demonstrated by the outcomes of the student's post-test. This aligns with the findings of a study conducted by Sa'adah & Luvy (2019) titled "The Impact of Mathematical Disposition on Critical Thinking Skills among Middle School Students." The findings of the study indicated that there was a significant positive correlation of 82.5% between students' mathematical propensity and their critical thinking ability.

Comparison of Students' Mathematical Critical Thinking Ability Based on Students' Mathematical Disposition Level

A post hoc test was carried out to compare students' mathematical critical thinking skills based on their level of mathematical disposition. The post hoc test results are presented in table 6 below.

Table 6. Post Hoc Test Results Comparison of Critical Thinking Ability Students' Mathematics in terms of Mathematical Disposition Level

Multiple Comparisons

Dependent Variable: math_critical_thinking_score
Tukey HSD

(I) Mathematical Disposition	(J) Mathematical Disposition	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
High	Medium	24.14*	4.070	.000	14.26	34.02
	Low	33.21*	5.756	.000	19.24	47.19
Medium	High	-24.14*	4.070	.000	-34.02	-14.26
	Low	9.07	5.255	.207	-3.68	21.83
Low	High	-33.21*	5.756	.000	-47.19	-19.24
	Medium	-9.07	5.255	.207	-21.83	3.68

Based on observed means.
The error term is Mean Square (Error) = 154.629.
*The mean difference is significant at the 05 levels.

Based on table 6, the results of the post-host test obtained the following information:

1. A comparison of students' mathematical critical thinking skills between students in the category of high and low levels of mathematical disposition is (sig. = 0.000 < α = 0.05), meaning that there are significant differences in students' mathematical critical thinking abilities between students with high and low levels of mathematical disposition. The average difference in students' mathematical critical thinking ability between students with high and low levels of mathematical disposition is 21, where the average critical thinking ability of students with high levels of mathematical disposition is greater than that of students with a low level of mathematical disposition.
2. The comparison of students' mathematical critical thinking skills between students with high and medium levels of mathematical disposition is significant (sig. = 0.000 < α = 0.05), meaning that there is a substantial difference in students' mathematical critical thinking abilities between students with high and medium levels of mathematical disposition. The average difference in students' mathematical critical thinking skills between students with high and moderate levels of mathematical disposition is 14, where the average critical thinking ability of students with high levels of mathematical disposition is greater than that of students with a moderate level.
3. The comparison of students' mathematical critical thinking skills between students included in the categories of medium and low levels of mathematical disposition is significant (= 0.207 > α = 0.05), meaning that there are differences in students' mathematical critical thinking abilities between students with

moderate and low levels of mathematical disposition; however, the differences are not significant. The average difference in students' mathematical critical thinking skills between students with moderate and low levels of mathematical disposition is 9.07, where the average critical thinking ability of students with moderate levels of mathematical disposition is greater than that of students with a low level of mathematical disposition.

According to the research results described above, students' mathematical disposition has a significant effect on students' critical mathematical thinking abilities. The results are in line with the research of Soedjoko, Kurniati, & Kurniasih (2019) which stated that students' mathematical dispositions influence students' creative thinking abilities.

When students with a high mathematical disposition can demonstrate all aspects of creative thinking, such as fluency, they can provide accurate answers and follow the correct procedures when solving problems.

Flexibility, or the capacity to provide the correct answer in a variety of ways, and novelty or originality, which suggests that students can provide answers using their own thoughts, and with their own ideas and different from others.

Meanwhile, students who have a moderate mathematical disposition can only master creative thinking indicators; they can fluently provide accurate answers with the correct steps in the process of solving problems. Flexibility is the ability to solve problems in various ways by giving the right one. Meanwhile, students who have a low mathematical disposition can only master one indicator of creative thinking, namely the fluency of students who can provide correct answers along with the appropriate steps in the process of solving problems.

In a study conducted by Lestari, Kartono, & Mulyono (2019), the students who possess a strong inclination towards mathematics have a high level of proficiency in various aspects, including communication, mathematization, reasoning and argumentation, and strategy design. Students with mathematical disposition demonstrated competence in the fundamental factors, including communication, mathematization, and the cultivation of problem-solving techniques. On the other hand, students who possess a limited inclination towards mathematics are only able to achieve a satisfactory level of proficiency in areas such as communication, mathematization, and the utilization of mathematical tools.

The research also strengthened the results of this study by Joko AB, Margono, & Rahayu (2018), which revealed that students' mathematical dispositions influenced students' problem-solving abilities in learning geometry. Minarti & Wahyudin (2019), in their research, also stated that students' mathematical dispositions affected students' mathematical communication abilities. As well as mathematical dispositions, they also affect students' mathematical strength and ability to think logically (Kusmaryono, Suyitno, & Dwijanto, 2019; Joko AB, Margono, & Rahayu, 2019).

The findings of this study also indicate notable disparities in students' mathematical critical thinking skills, depending on the extent of their mathematical

tendencies. The academic literature suggests that students exhibiting a strong inclination towards mathematics manage to obtain higher scores in mathematical critical thinking skills compared to their peers with moderate or low inclinations towards mathematics. In contrast, the students indicating poor mathematical dispositions showed the least proficiency in mathematical critical thinking when compared to their counterparts with high and moderate mathematical dispositions. This discrepancy can be attributed to the significant influence of students' mathematical disposition, which is recognized as a crucial determinant of their academic achievement in mathematics (Feldhaus, 2014).

The findings in this study are also in line with the results of Arifin, Wahyudin, & Herman (2021) research, which states that students with high self-efficacy have better conceptual understanding and mathematical reasoning abilities than students with moderate and low self-efficacy. Conversely, students with low self-efficacy have lower competence to comprehend concepts and mathematical reasoning than students with high and moderate self-efficacy do.

CONCLUSION

Based on the analysis of the research findings, there is a positive correlation and a statistically significant impact on students' mathematical inclination toward their mathematical critical thinking abilities. The varying levels of students' mathematical dispositions have an influence on their respective mathematical critical thinking abilities. Students with a heightened mathematical disposition have superior mathematical critical thinking compared to their peers with moderate and low degrees of mathematical disposition. Hence, educators must consider the mathematical disposition of their students while teaching mathematics in schools, as it exerts a noteworthy impact on their capacities to engage in critical thinking within the realm of mathematics.

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