

THE EFFECT OF STEM-BASED MATHEMATICS LEARNING ON CRITICAL THINKING ABILITY OF STUDENTS OF AN NUJABA PRIMARY SCHOOL

Ahmad Sahabudin¹, Parhaini Andriani², Muhammad Ghazali³

^{1,2,3}Department of Mathematics Education, Faculty of Tarbiyah and Keguruan, Universitas Islam Negeri Mataram, Indonesia

Email: ¹190103045.mhs@uinmataram.ac.id, ²parhaini.andriani@uinmataram.ac.id, ³ghazali@uinmataram.ac.id

ABSTRACT

Critical thinking skills are one of the most important 21st century skills for students, and the fact that students' abilities are lacking due to their involvement in the classroom is critical thinking skills. The purpose of this research is to prove that teaching mathematics concepts in STEM schools has or does not have an effect on the critical thinking skills of elementary school students. This research is qualitative with a *quasi-experimental* type. This study involved 20 Grade V students at SDIT An-Nujaba' Mataram who were included as a sample selected by the saturated sampling technique, the instrument used in this study was a critical thinking ability test. The analysis technique uses the t-test (*paired sample t-test*). The results of this study indicate that there is a p-value = 0.000 which indicates a significant difference before and after the application of STEM-based mathematics learning. The findings of this study indicate that, with the support of STEM mathematics education, students' critical thinking skills have a significant effect. The research of STEM-based learning in critical thinking skills.

Keywords: *Critical thinking skills, STEM-based mathematics learning.*

*** Corresponding Author Email:** 190103045.mhs@uinmataram.ac.id

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INTRODUCTION

The complexity of the global world demands high-level thinking skills, including critical thinking. Therefore, critical thinking skills are one of the competencies that must be possessed by students in school, including in learning mathematics. However, the fact is that students' mathematical critical thinking skills are still low, especially in the aspects of analysis, evaluation and inference (Parameswari and Kurniyati, 2020).

Critical thinking skills are an important aspect of learning mathematics. When students use their critical thinking skills in math, they not only know how to solve the problem, but they also understand why the given solution can solve the problem. In addition, students also use critical thinking skills when they determine the best strategy to solve the problem. Students who think critically in mathematics can develop several things: (a) deeper student engagement and understanding; (b) greater independence and self-regulation; and (c) stronger competence with mathematical processes (Florea, N. M., & Hurjui, 2015).

Based on the results of the initial study in class V SDIT An-Nujaba obtained information that students' ability to think critically in mathematics lessons is still lacking. This can be seen from the results of the test in the form of description questions. Students when given a problem in the problem are still unable to identify the problem and still find it difficult to explain the meaning of the problem. This is due to the lack of student concentration when receiving teacher explanations so that most students' problem solving feedback does not get scores above the KKM (Rina, 2023).

The development of critical thinking skills will be effective if it meets certain conditions, including: the creation of learning situations and appropriate time allocations; activities that encourage children to think independently, speculate, reflect; acceptance of diversity of opinions and ideas; active involvement with confrontation of ideas, cooperation and collaboration in finding the right solution; confidence that children will not be ridiculed for opinions; every belief in the ability to think critically; appreciation of critical thinking (Florea, N. M., & Hurjui, 2015). One of the latest learning that can fulfill the criteria of learning that develops critical thinking skills is using the STEM (science, technology, engineering, and mathematics) learning approach.

STEM is a learning approach that integrates the four fields of science, technology, engineering and math into a holistic whole. This approach is different and complementary to classroom learning. STEM learning integrates science, technology, engineering and mathematics through technology, teaching, techniques and learning strategies so that learners can be encouraged to apply knowledge not just understand it at every moment (Lou *et al.*, 2014). STEM can help students apply their knowledge, collaborate with friends and can identify their interests by learning through STEM (Ahmad, Yakob and Ahmad, 2019). The STEM approach allows students to be more innovative, independent and logical thinkers to solve problems. In the critical thinking process, analysis of a problem must be considered.

Several studies related to STEM learning show positive results. Laili Rahmawati *et al* (2022), found that the STEM approach has a positive influence on improving students' mathematical creative thinking and critical thinking skills (Rahmawati, Juandi and Nurlaelah, 2022). The results of Ilyas Yusuf's research show that there is an increase in critical thinking skills and student learning motivation after applying the STEM approach in learning. Students' critical thinking skills after applying the STEM approach increased from very low to high categories (Yusuf, Ma'rufi and Nurdin, 2022). according to research (Mardhiyatirrahmah, L., Muchlas, M., & Marhayati, 2020), The STEM approach used in mathematics learning has a positive impact on students, such as mathematics learning outcomes and affective and psychomotor mathematical attitudes. Students become more active in learning, increase the desire to help each other, feel confident and know how to respect others and themselves. The STEM approach is also influenced by several factors, such as local government cooperation with schools, appropriate strategies to support such a large student population, national policies, economic background, ethnicity, time spent in teaching and learning, learning models used and students' habits in learning mathematics (Mardhiyatirrahmah, L., Muchlas, M., & Marhayati, 2020).

Science, Technology, Engineering and Mathematics (STEM) based learning that integrates various disciplines with active processes and connects them to everyday life is closely related to QS. Al-Imron: 190-191, namely (Atika, 2022):

Meaning: *"Surely in the creation of the heavens and the earth and the alternation of the day and the night are signs for the intelligent (i.e.) those who stand or sit or lie down and they think about the creation of the heavens and the earth (saying): O our Lord, you have not created this in vain, glory be to you, so protect us from the punishment of hell"*

According to the tafsir, Allah obliges His people to seek knowledge and commands them to use their intellect to contemplate nature, the heavens and the earth, understand the provisions that show the majesty of the Almighty, knowledge and the alternation of day and night. So it is a sign for those who think it will not happen by itself. In return, the results of that thinking should be used by mankind to reflect and analyze everything that exists in this universe so as to create knowledge. The word "thinking" is used to describe someone who is intelligent. The events that occur on this planet and of course to increase faith in the one who created it will always be studied by an intelligent person. Thinking about it, we will understand that this is all the work of the great God. In accordance with the study of science, technology, engineering and STEM education methods that students should think about problem identification, acquiring new knowledge, understanding what STEM disciplines look like as a form of

human endeavor involving investigation, design, analysis processes or using them for everyday life (Atika, 2022).

Based on the various explanations above, it can be understood that the application of STEM-based learning is important to be implemented at various levels of education, including elementary schools. The purpose of this study is to determine whether there is an effect of STEM-based mathematics learning on the critical thinking skills of elementary school students.

METHOD

The approach used in this research is quantitative with the type of *quasi experiment*. While the research design used is *one group pretest posttest design*. In this design, before the treatment is given first the sample is given a *pretest* (initial test) and at the end of the learning the sample is given a *posttest* (final test). This design is used in accordance with the objectives to be achieved.

The research was conducted at SDIT AN-Nujaba in the even semester of the 2023/2024 academic year. The population of this study were all students in grades V and VI of SDIT AN-Nujaba, totaling 20 students. The research sample was selected using a saturated sampling technique where the entire population was used as a sample. This technique is usually used when the population is relatively low, namely 20 people or the study wants to draw generalizations with a very limited number of errors.

The instrument test used in this research uses expert opinion (expert Judgment) to analyze the pretest and posttest. The experts in this research are a mathematics lecturer in the *tadris* Mathematics study program at the when the instrument has been approved by experts, it is feasible to measure the desired aspect.

The instrument used is a critical thinking ability test on the material of building space in the form of essay questions. This test consists of *pretest* and *posttest*. The purpose of the pretest is to determine the initial ability of students while the posttest is done to measure and know the extent of the difference in the improvement of students' critical thinking skills after being given treatment / learning process. The data analysis technique used in this study is a two-average difference test using the *t-test* (*paired sampled t-test*) with a significance level of $\alpha = 0.05$ to test the hypothesis. Before doing the *t* test, a prerequisite test must first be carried out in the form of a normality test using the Shapiro-wilk test.

RESULT AND DISCUSSION

Implementation of STEM-based Mathematics Learning

STEM implementation in mathematics learning can be done well when the teacher as a learning companion has understood the meaning of an implementation. STEM implementation is the process of applying the ideas and concepts of the STEM approach in a lesson that will influence and improve education for the better. The application of STEM ideas and concepts in mathematics learning means that the process of constructing mathematical concepts carried out in a learning process must be followed by the ideas of the disciplines contained in STEM, namely science, technology, engineering, art and mathematics. Mathematics itself is one of the disciplines integrated in STEM, so the implementation of STEM in mathematics learning only applies the ideas of other disciplines, namely science, technology, engineering and art (Nurhikmayati, 2019).

In mathematics learning, STEM implementation can be done by understanding the relationship between existing mathematical concepts and other disciplines contained in STEM. The relationship between these concepts can be built through critical thinking skills, creativity and problem solving skills so that it will produce an idea or complex skills to formulate a solution to the problem at hand. The implementation of STEM is done in an integrated manner, meaning that the approach taken is to connect the disciplines of science contained in STEM with existing mathematical concepts to produce an idea, idea, solution or product (Nurhikmayati, 2019).

Some examples of STEM implementation in mathematics learning include the following (Nurhikmayati, 2019):

1. Learning the material of building space can be done by using math software technology with the technique of making building space more interesting and easier. In designing the building

- space, students can add elements of art, namely the addition of color so that the building space obtained will be more interesting to learn.
2. Learning the material of opportunity can be done by doing a project to make props for the concept of opportunity. Learners make props by designing directly according to their knowledge and interests. The props that are designed can be done with their respective techniques and students can add elements of art to the making of these props so that they are attractive to use. Props made can then be tested on several math problems to solve problems.
 3. Learning social arithmetic material can be done by making processed products from various foods, such as fruits or vegetables. Learners are asked to make posters, e-posters or short videos on the website to market their processed products. Learners are also required to conduct buying and selling transactions with consumers they meet either directly or online. All aspects of STEM disciplines will be integrated in this lesson.
 4. Learning trigonometry material can be done by giving a project. Learners are told to calculate the elevation angle of a building. Learners in groups will observe, measure and analyze with different techniques. In the field of technology, students can use the internet to find data in completing the project. The results of the project can be made in the form of a presentation where learners can add elements of art to the making of power points that will be presented.

The application of STEM-based math learning in this research uses a project tower made of sticks and Styrofoam pieces. STEM-based mathematics learning was carried out in 3 face-to-face sessions. The first meeting was held on Tuesday, June 20, 2023 on the date and time of the *pretest*. Learning In accordance with the lesson plan that has been submitted, the researcher continues learning in the class after the initial test with the material of building space through STEM-based learning. Students are divided into 3 groups (LKS1) on the task of LKS 1 students are involved to design and design tower buildings (project) using the tools and materials that have been explained in LKS 1, then they join their respective groups. The teacher and students provide questions to discuss or work on in LKS 1 and are guided by the teacher in working on the project until it is completed. Together with the researcher explain the relationship between the project (STEM) and the material to be discussed (building space).



Figure 1. STEM-Based Learning Activity Process

In the second meeting students began to understand, learn to remember the previous material, and were able to find directions in the Student Worksheet (LKS 2) independently so that students could complete LKS 2 with the materials on the previous day. In LKS 2 students are involved in designing and designing or continuing the tower building (project) in the previous lesson. And students can

immediately connect the project to complete LKS 2 so that students can present the results of work on LKS 1 and LKS 2 to completion. At the third meeting, the teacher gave and explained the questions and answers on the material of building space before giving the final test (*posttest*).

Description of *Pretest* and *Posttest* Results

The following are the results of student work before (*pretest*) and after (*posttest*) being treated based on indicators of students' critical thinking skills which can be seen in the visual documentation. In this indicator, 2 questions are tested with activities asking students to interpret, analyze, evaluate, invert. The following is visual documentation of the results of student answers on the *pretest* and *posttest*.

- No.1 *Pretest*

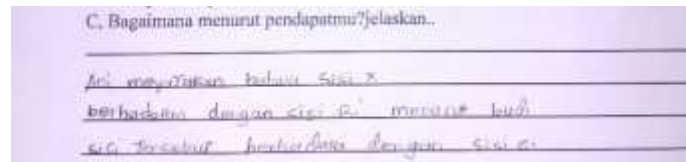


Figure 2. *Pretest* Student Answers

From the students' answers in Figure 2, it can be seen that in this question, the interpretation indicator is correct, but in the indicators of analyzing, evaluating, inferring, students have not used the critical thinking indicator procedure completely.

- No.2 *Pretest*

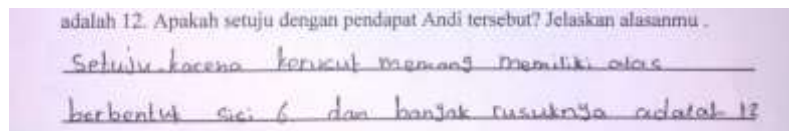


Figure 3. *Pretest* Student Answers

From the students' answers in Figure 3, it can be seen that in this problem students do not interpret, but students analyze the problem, and students are less precise in evaluating the problem, and students do not infer / conclude the problem.

- No.1 *Posttest*

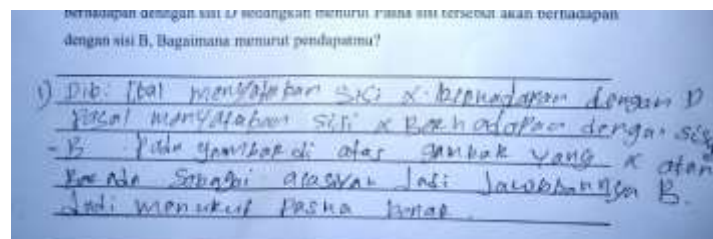


Figure 4. *Posttest* Student Answers

From the students' answers in Figure 4, it is noted that in this question students have been able to interpret the problem, and students are able to analyze the problem, but students are less precise in evaluating the problem, and students do not infer / conclude the problem clearly.

- No.2 *Posttest*

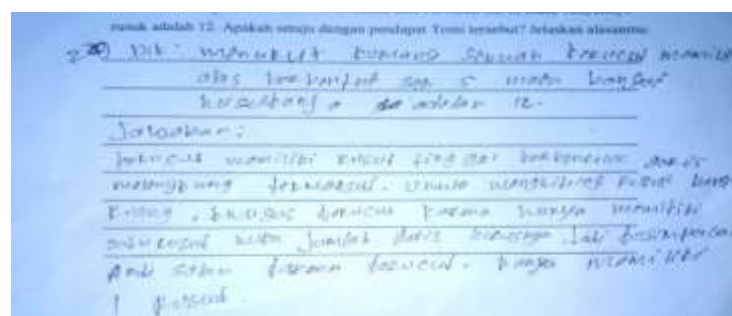


Figure 5. *Posttest* Student Answers

From the students' answers in Figure 5, it can be seen that in this question students are correct in interpreting, analyzing, and evaluating the question, and students are good at inferring / concluding the question.

On Monday, June 20, 2023, the test will be held at the first meeting. First, researchers discussed with students, then explained a little about the first meeting. To determine the effect of STEM-based mathematics learning on students' critical thinking skills in the material "building space", researchers conducted an initial test. A total of two validated questions that lasted for 2 x 35 minutes. Data on students' pretest scores are as follows:

Table 1. Pretest Result Statistics

Maximum Value	Minimum Value	Average	Median	Mode	Standard Deviation	Variance
65	10	31,32	30	30	16,40	269,14

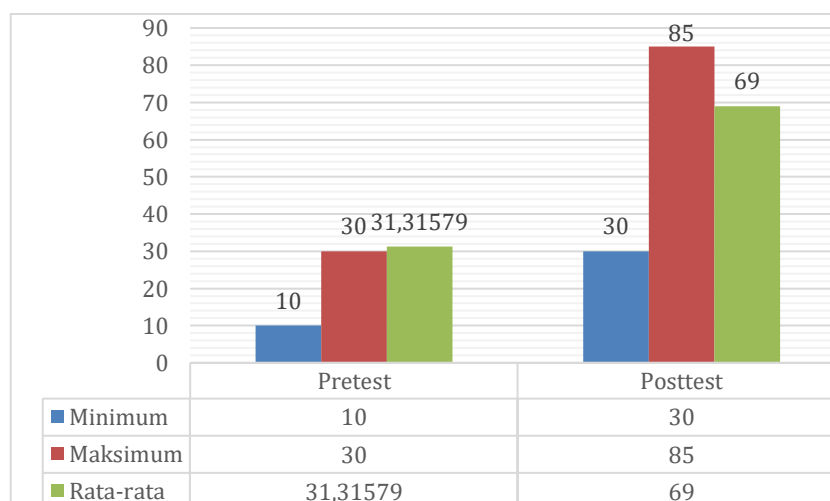
Based on the Pretest results data in Table 1, the maximum score achieved by students is 65, while the minimum score is 10 with an average of 31.31579 and median 30 while mode 30 with a standard deviation of 16.40 with a variance of 269.14 from 20 students. Furthermore, the posttest was carried out on June 22, 2023 where the researcher had given sample questions before conducting the Posttest on Spatial Buildings Material. For 3 x 35 minutes, the last test was carried out on 2 questions that had been tested for validation.

At the last meeting, researchers conducted a final test (*posttest*) to determine the effect of students' critical thinking skills after teaching material with a STEM-based learning model and obtained posttest results as shown in the statistics below:

Table 2. Posttest Result Statistics

Maksimum Value	Minimum Value	Average	Median	Mode	Standard Deviation	Variance
85	30	69	74	60	13,085	171,22

Based on the *posttest* data in Table 2, the maximum score achieved by students is 85, while the minimum score is 30 with an average of 69 and median 74 while mode 60 with a standard deviation of 13.085 with a variance of 171.22 from 20 students. Critical thinking skills of Class V students can also be seen when STEM-based learning is applied, from before to and after treatment. The increase in students' critical thinking skills with STEM-based mathematics learning models can be seen from the results of the *pretest* and *posttest* data below:

Figure 6. Comparison chart of *pretest* and *posttest* results

Based on the picture that can be seen above, the maximum score on the test is 30 and the lowest is 10 with an average of 31.31. At this stage, students do not understand the material "build space" and it will be difficult for students to distinguish the sides of the ribs and the base. That there are still many students who do not know how to distinguish the most important sides, ribs and nets when answering questions. There is a group of students who only respond to what they know from the question. In comparison, the highest score of 85 was recorded on the posttest and the lowest score was 30 with an average score of 69. Students' understanding of the material "Building Spaces" was good at this point. Thus, students not only write down what they know when working on the problem but also answer it more clearly which means that the average student will be able to understand the problem well.

Prerequisite Test

Normalization test to determine whether the data for the difference between *pretest* and *posttest* scores are normally distributed. The normality test is a prerequisite test for continuing the t-test.

Table 3. Normality Test Result

	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	Df	Sig.
Selisi	.110	20	.200*	.969	20	.725

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Based on the calculation results of Table 3, it can be analyzed as follows. We see that the significance value of *Shapiro-wilk* is 0.725 and *Kolmogorov-Smirnov* is 0.200. This research sample is a small sample of 20 samples. So that the significance used in the normality test, namely *Shapiro-Wilk*, is 0.725. The significance value is greater than 5% or 0.050 so we can conclude that the data is normally distributed.

Hypothesis Test

The hypothesis test used in *this* study is the *t-test (paired sample t test)* in this study used to answer the problem formulation "Is there an effect of STEM-based learning on the critical thinking skills of SDIT An Nujaba students?". The effect is seen by comparing the value between before treatment (*pretest*) and after treatment (*posttest*), following the statistical results of hypothesis testing:

Table 4. Paired Sample t -test Result

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% C.I. of the difference				
					Lower	Upper			
Pair1	Pre-Post	-37.45000	16.84441	3.76652	-45.33343	-29.56657	-9.943	19	.000

Based on the output results in Table 4, it can be analyzed as follows. In the paired samples test table above, it is known that the significance value of 0.000 is less than 0.05 or $t_{hitung} < t_{tabel}$, so there is an effect or the hypothesis is rejected (H_0 is rejected) there is a difference between pretest and posttest. The data above is taken from samples on pretest and posttest students with a total of 20 students with an average value of 31.75 and 69.2. So that the resulting significance value between before treatment (pretest) and after treatment (posttest) is 0.000 less than the value of $\alpha = 0.05 = 5\%$, which means that the t-test obtained the Criteria value accept H_0 so do not accept but reject H_0 . Because rejecting H_0 means we accept H_a , the conclusion is that there is a difference, meaning that there is an effect of STEM-based math learning on the critical thinking skills of fifth grade students of SDIT AN-Nujaba.

The results of data analysis showed that there was a significant difference between the *pretest* and *posttest* results of students' thinking skills. Thus, STEM-based mathematics learning significantly affects students' mathematical critical thinking skills. This shows that the use of STEM mathematics education has a positive impact on students' critical thinking skills. Students' critical thinking skills will increase as a result of improving STEM-based mathematics education. This is in line with research (Yusuf, Ma'rufi and Nurdin, 2022) who found that the application of the STEM approach in learning

can improve students' critical thinking skills and learning motivation. Students' critical thinking skills after applying the STEM approach increased from very low to high categories. In addition, there is also almost the same thing found in research Febril et al. (2022) where the critical thinking skills of students taught the STEM-based math learning model were higher than those obtained in the standard teaching method. Similarly, when students learned math problem solving skills using the STEM method the average score was higher than if they learned the conventional model.

These studies show a significant effect of STEM-based learning on critical thinking skills. This is because critical thinking is one of the important elements in problem solving in science, technology, engineering, and mathematics (STEM) education (NATIONAL ACADEMIES PRESS (US), 2006). The STEM approach to problem solving has the following principles; using critical thinking to recognize problems, using math, science, technology, and engineering concepts to evaluate problems, and correctly identifying the steps needed to solve problems (NATIONAL ACADEMIES PRESS (US), 2006). This principle is also applied to the STEM-based mathematics learning conducted in this study where elementary school students are involved in designing and building a tower frame using simple tools and materials.

In STEM-based learning, students are engaged in integrated learning related to real-world problems. Students of all ages find ways to apply critical thinking to real-world situations and problems through integrating various content and practical skills from disciplines through the use of technology. STEM programs strive to develop innovative methods and solutions that are more effective, elegant, scientifically based and technological. New knowledge is needed at an increasing pace in our rapidly evolving technological and global society.

So from the above results it can be said that the critical thinking skills of students taught using STEM are better than students taught with conventional learning. This can be seen from the average posttest obtained by students is higher than the average pretest value. The difference in critical thinking skills described in the form of differences in average scores obtained from differences in STEM-based mathematics learning models used.

Differences resulting from other learning with STEM-based mathematics learning model on critical thinking skills of students who focus on four indicators of critical thinking skills namely interpreting, analyzing, evaluating, and concluding. conclude. Instrument questions on the critical thinking ability test students' mathematical critical thinking skills test is based on four indicators that indicators that have been determined based on the operational definition that has been made. Improvement of students' critical thinking skills in mathematics using the STEM-based mathematics learning model learning model showed that the posstest students' answer scores were better than pretest students and the critical thinking ability of mathematics posttest students are better than pretest students.

CONCLUSION AND SUGGESTIONS

This study found that using STEM-based learning in math can greatly improve elementary students' critical thinking skills. We saw this improvement in the students' posttest scores, which were higher after the STEM lessons. This result was statistically significant, with a p-value of 0.000 (below the 0.05 threshold), meaning there is a clear difference between the pretest and posttest scores. the STEM-based approach had a positive impact on students' critical thinking in math. The study suggests that STEM-based math learning can be an effective way to boost students' critical thinking, especially when it fits well with the topics being taught. This study recommends the need to use STEM-based mathematics learning as one possible alternative to improve students' critical thinking skills, especially in Mathematics subjects, which are in accordance with the learning material to be taught and can be imagined. Further research is encouraged to explore how STEM learning affects other skills and areas.

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