

# **THE EFFECT OF LEARNING WITH STEM APPROACH TO MATHEMATICAL REASONING ABILITY AND THINKING CRITICAL STUDENTS**

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## **ABSTRACT**

The purpose of this study was to determine the effect of learning with the STEM (Science Technology Engineerig and Mathematics) approach to the ability of mathematical reasoning and critical thinking in class XI Negeri 7 Denpasar students. This type of research is classified as Quasi Experiment with Non Equivalent Posttest-Only Control Group Design research design. The population in this study were all 10th grade students of MIPA Senior High School 7 Denpasar with 10 classes with a total of 360 students. With random sampling technique, 4 classes were taken as samples, namely XI MIPA 2 and 4 classes with 72 students as the experimental group and MIPA 3 and 5 XI classes with 72 students as the control group. The data obtained are quantitative data in the form of mathematical reasoning ability scores and critical thinking using the test method. Analysis using manova with the help of SPSS 22.0 for Windows.

Based on the hypothesis test obtained: (1) there is the effect of learning with the STEM approach to mathematical reasoning abilities; (2) there is an effect of learning with the STEM approach to critical thinking skills; 3) there is a simultaneous influence of learning with the STEM approach to the mathematical reasoning ability and critical thinking of class XI students of SMA Negeri 7 Denpasar in the academic year 2018/2019. Learning with the STEM approach can foster understanding of the relationship between principles, concepts, and domain skills in certain disciplines and arouse curiosity encouraging problem solving collaboration and interdependence in student group work and triggering their creative imagination and critical thinking.

Keywords: Learning, STEM, Mathematical Reasoning, Critical Thinking

## **PRELIMINARY**

One effort to develop students' reasoning and critical thinking skills is through education. According to Law No. 20 of 2003 concerning the National Education System in article 1 paragraph 1, namely education is a conscious and planned effort to create an atmosphere of learning and learning process so that students actively develop their potential to have religious spiritual strength, self-control, personality, intelligence, noble character, and the skills needed by himself, the community, nation and state. One of the subjects in the world of education that focuses on developing reasoning and critical thinking skills is mathematics.

In essence, learning mathematics is learning to solve problems. This is in accordance with the learning objectives of mathematics included in Permendiknas No. 22 of 2006 concerning one of the objectives of learning mathematics is the concept of

mathematics, explains about mathematical concepts and applies a broad, accurate, efficient, and appropriate algorithm in solving problems. In this case mathematics requires mathematical ability and critical thinking for those who study it published about the ability to think in analyzing problems and the ability of mathematical punishment to create alternative problem solving.

Based on the results of research and interviews with class XI teachers of SMA Negeri 7 Denpasar about mathematical reasoning abilities and students' thinking abilities, students have high abilities, higher abilities, and there are still those in the less category. The efforts made by teachers so far to improve students' mathematical punishment and critical thinking skills have not yet been fully approved. They do not mean to think higher level. The learning used by the teacher is direct learning. Direct learning is learning that is still approved by the teacher where the teacher delivers the material directly to students. Students are still passive and do not like learning so students accept what the teacher says. Students sit on a bench while listening to a teacher who is reading a book. After the teacher finishes explaining the students work on the practice questions in the book. The teacher only focuses on improving student learning outcomes by giving practice questions to students, then giving a grid before the test is held.

STEM Education Definition as a discussion and learning that integrates the concepts of technology / techniques in learning science / mathematics. STEM learning (Science, Technology, Engineering, and Mathematics) is learning that uses interdisciplinary learning where the application is carried out with active learning based on conflict (Muharomah, 2015). The definition of STEM in learning is expected to produce learning that helps students through knowledge, concepts, and skills systematically. Through STEM consideration, students will have a different way of thinking and develop critical power and make thought, so that they can apply various sciences. In addition, students will be able to solve problems well.

Based on observations that have been made, it can be explained several indicators that show the low ability of mathematical punishment and critical thinking of students in learning mathematics, as described below. (1) when the teacher explains the lesson, students just sit quietly listening to the teacher's explanation, students rarely ask questions or provide responses, (2) the compilation of teachers asks students to provide arguments, then students cannot give questions or support clearly and logically, (3 ) students are not careful / thorough in completing their own work or work done by the teacher, so the teacher compilation is wrong in writing something on the blackboard, but students just stay quiet and cannot justify the mistakes, (4) the teacher is only fixated on one form only, students are not able to give new agreement to other alternative forms, (5) many students are unable to formulate the points of debate needed in a problem-solving problem, (6) many students cannot detail the ways of solving a problem, starting from understanding things that are recognized, then yes, later clarifying the details of the steps.

The ability of mathematical reasoning helps students in concluding and proving a statement, building new ideas, until solving problems in mathematics. Therefore, mathematical reasoning ability must always be familiarized and developed in every

mathematics learning. The habituation must start from the teacher's consistency in teaching, especially in giving non-routine questions. Reasoning is divided into two, namely deductive reasoning and inductive reasoning. Deductive reasoning is a way of thinking in which from general statements drawn conclusions that are specific, drawing conclusions using syllogism. Inductive reasoning is a way of thinking where general conclusions are drawn from various individual cases. In learning mathematics the ability of reasoning can be developed when students understand a concept or find and prove a principle. When finding or proving a principle, an inductive and deductive mindset is developed. Students are accustomed to seeing the characteristics of several cases, seeing patterns and making assumptions about the relationships that exist between those cases, and then expressing generally accepted relationships.

To improve students' mathematical reasoning and critical thinking abilities, teachers should choose and use strategies, approaches, methods or techniques that involve students actively in learning, both mentally, physically and socially. So that not only will mathematical reasoning and critical thinking skills increase, but learning outcomes can also improve. If related to teaching theory with Bruner's psychological approach (Wahyudwiyanto, 2013). Learning that should be applied by a teacher in his class is one that not only considers the effectiveness of learning in terms of learning, but also how students obtain information and solve problems. Learning to find and solve problems results in the exploration of a number of alternatives that ultimately create the urge to think until knowledge is obtained.

The ability to think critically plays an important role in improving the quality of human resources. This ability to think critically has become a very popular term in the world of education in recent years. The teacher becomes more interested in teaching thinking skills with various styles. Critical thinking enables students to find truth in the midst of a flood of events and the information that surrounds them. Therefore, critical thinking needs to be taught both specifically and independently and in an integrated manner in every discipline or across the curriculum in order to improve learning effectiveness. This can be done especially in mathematics education which is oriented towards improving students' cognitive skills. Critical thinking is an embodiment of higher level thinking. Critical thinking is an ability to systematically evaluate the quality of thinking of oneself and others.

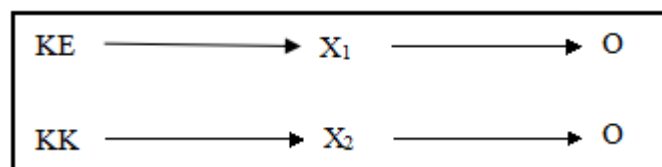
Starting from this condition, one of the teacher's efforts that can be done is to apply the latest learning that is fun and can improve the ability of mathematical reasoning and critical thinking. One of them is by applying learning with the approach of Science, Technology, Engineering, and Mathematics (STEM). Learning with the STEM approach is able to build competencies such as curiosity, creativity, tolerance and ambiguity. Through the STEM approach students will have different ways of thinking and develop critical power and shape thinking logic, so that it can be applied in various sciences. Learning with the STEM approach has an important role in modern education, because currently students who will later become the next generation of the nation will face more complex problems in the future.

The purpose of this study are as follows: (1) To determine the effect of learning with the STEM approach to students 'mathematical reasoning abilities, (2) To

determine the effect of learning with the STEM approach to students' critical thinking abilities, and (3) To determine the effect simultaneously learning with the STEM approach to the mathematical reasoning ability and critical thinking of class XI students of SMA Negeri 7 Denpasar in the academic year 2018/2019.

## RESEARCH METHODS

This research is included in the type of experimental research with the experimental research design used is quasi experiment. Researchers use quasi experimental design with the reason researchers can't control or control the variable strictly or in full. The quasi-experimental design model used is the Non Equivalent Posttest-Only Control Group Design. In this design the experimental group and the control group were chosen randomly. The experimental group was treated by using learning with the STEM approach, while the control group used conventional learning. The description of the Non Equivalent Posttest-Only Control Group Design is as follows:



Picture 1

Non Equivalent Posttest-Only Control Group Design Research Design Information:

TO: Experiment Group

KK: Control Group

X1: Treatment in the form of application of learning with STEM approach

X2: Treatment in the form of application of conventional learning

O: Posttest mathematical reasoning ability and posttest critical thinking skills after learning is carried out

The population in this study were all students of class XI of SMA Negeri 7 Denpasar in the 2018/2019 academic year consisting of 10 classes. The sample in this study was taken by simple random sampling technique, but randomized was class. The sample in this study was taken by simple random sampling technique, but the randomized class. In this case the dependent variable is the ability of mathematical reasoning and critical thinking in mathematics.

To test the data collected, the data were analyzed using prerequisite test analysis and multivariate analysis of variance test (manova) with the help of the SPSS 22.0 for Windows program. Testing normality with SPSS 22.0 for Windows with the Kolmogorov – Smirnov technique. If the significance number is greater than 0.05, then the sample comes from populations that are normally distributed. Homogeneity test is done to determine whether the sample from the control group or the experimental group comes from homogeneous variance. Multicollinearity test is performed to determine whether there is a significant correlation between independent variables.

To test hypotheses I, II, and III used the manova test (Multivariate Analysis of Variance) because in the manova test also tested the dependent variable between

different groups. The test results will be shown in the Test of Between-Subjects Effects table.

## RESEARCH RESULT

The research data were obtained using research instruments that have been tested for validity and reliability. Furthermore, the data obtained were analyzed statistically both descriptive and inferential. Analysis of descriptive statistical research data (centralization and dissemination of data) with the recapitulation as follows.

Table 1. Summary of Descriptive Statistics of Mathematical Reasoning Capability Data and Critical Thinking Students in the Experiment Group and Control Group

No.	Data Statistik	Kemampuan Penalaran Matematis		Kemampuan Berpikir Kritis	
		Kelompok Eksperimen	Kelompok Kontrol	Kelompok Eksperimen	Kelompok Kontrol
1.	Rata-rata	72,17	64,44	76,37	69
2.	Median	72,23	64,17	77	67,64
3.	Modus	73,5	69,32	84,21	66,35
4.	Varians	151,38	153,25	173,33	194,4
5.	Standar Deviasi	12,31	12,38	13,17	13,94
6.	Skor Maksimum	94	94	100	94
7.	Skor Minimum	44	38	50	44
8.	Rentangan	50	56	50	50

Homogeneity variance test is performed on the mathematical reasoning ability data between the experimental group and the control group and on the critical thinking ability data between the experimental group and the control group. Homogeneity variance test is seen from the results of the Levene's Test of Equality of Error Variances. If the price of the Leven's Test of Equality of Error Variances is significant then the data is homogeneous. The results of tests with SPSS 22.0 for Windows appear in Table 2 below.

**Tabel 2. Levene's Test of Equality of Error Variances<sup>a</sup>**

	F	df1	df2	Sig.
TKPM	.120	1	69	.730
TKBK	.068	1	69	.794

*Tests the null hypothesis that the error variance of the dependent variable is equal across groups.*

*a. Design: Intercept + model*

Based on SPSS 22.0 for Windows output, sig values are obtained. greater than  $\alpha = 0.05$  for both groups of data. This means that the population data of mathematical reasoning ability and critical thinking between the experimental group and the control group has homogeneous variance.

To find out whether there is a significant correlation between the dependent variables, a multicollinearity test is performed. Multicollinearity test seen from the Coefficient test results. The test results with SPSS 22.0 for Windows appear in the following Table 3.

**Tabel 3. Coefficient<sup>a</sup>**

Model	Unstandardizes Coefficients		Standardized Coefficients	T	Sig.	Collinearity Statistics		
	B	Std. Error	Beta			Tolerance	VIF	
	1	(Constant)	2.234			.305		
	TKPM	-	.009	-.602	2.358	.021	.196	5.107
	TKBK	.002	.009	.290	1.138	.260	.196	5.107
		.010						

a. Dependent Variable: model

Based on SPSS 22.0 for Windows output, the dependent variable obtained is the ability of mathematical reasoning and critical thinking has a VIF value of  $5.107 < 10$  or the value of the dependent variable has a tolerance value of  $0.196 > 0.1$ , then the dependent variable does not experience multicollinearity and linear analysis can be performed.

Homogeneity test of variance / covariance matrix is seen from Box test results. If the price of Box's M is significant, the null hypothesis which states that the variance / covariance matrix of the same dependent variable is rejected. In this condition the analysis of manova cannot proceed. Box's M test results with SPSS 22.0 for Windows appear in Table 4 below.

**Tabel 4. Box's Test of Equality of Covariance Matrices**

Box's M	4.077
F	1.316
df1	3
df2	880158.282
Sig.	.267

Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.

a. Design: Intercept + model

Based on SPSS 22.0 for Windows output, sig values are obtained. equal to 0.267 > 0.05, so  $H_0$  is accepted and  $H_1$  is rejected which means the dependent variable is the ability of mathematical reasoning and critical thinking having the same variance-covariance matrix in the independent variable group that is learning with the STEM approach.

The test results are based on Pillai's Trace, Wilks Lambda, Hotelling's Trace, and Roy's Largest Root. In this test, obtained in column sig. figures of 0.008. It turned out that the sig value < 0.05, so that  $H_0$  was rejected and  $H_1$  was accepted, which means there was a simultaneous influence of learning with the STEM approach to the mathematical reasoning ability and critical thinking of class XI students of SMA Negeri 7 Denpasar in the academic year 2018/2019.

## **DISCUSSION**

### **1. Hypothesis I**

The results of inferential statistics in the form of the analysis of the first hypothesis test with the analysis of manova obtained the conclusion that  $H_0$  is rejected and  $H_1$  is accepted. The results of manova testing with the help of SPSS 22.0 for Windows are based on Test of Between-Subjects Effects. In this test, obtained in column sig. figures of 0.004 which are based on test criteria if the sig value < 0.05 then it is interpreted that  $H_0$  is rejected and  $H_1$  is accepted, which states that there is an influence of learning with STEM approach to the mathematical reasoning ability of class XI students of SMA Negeri 7 Denpasar in 2018/2019 . The effect on the mathematical reasoning ability is seen from the results of the descriptive statistical analysis of the data which shows that the group of students who take learning using the STEM approach has an average score of mathematical reasoning ability score of 72.17 more than the average value of the group of students who take conventional learning namely 64.17.

Learning with the STEM approach is a teaching and learning approach that integrates the concepts of technology / techniques in learning science / mathematics. Learning with the STEM approach is expected to produce meaningful learning through systematic integration of knowledge, concepts and skills. Students are invited to think comprehensively with problem solving patterns is the application of learning based on aspects in STEM. Learning with the STEM approach will be able to improve students' mathematical reasoning abilities because through the STEM approach students will have different ways of thinking and form logical thinking, so that it can be applied in various sciences.

### **2. Hypothesis II**

Inferential statistical results in the form of a second hypothesis test analysis with the analysis of manova concluded that  $H_0$  is rejected and  $H_1$  is accepted. The results of manova testing with the help of SPSS 22.0 for Windows are based on Test of Between-Subjects Effects. In this test, obtained in column sig. figures of 0.036 which are based on test criteria if the sig value < 0.05 then it is interpreted that  $H_0$  is rejected and  $H_1$  is accepted, which states that there is an effect of learning with the STEM

approach to the critical thinking skills of class XI students of SMA Negeri 7 Denpasar in the 2018/2019 school year . The effect on critical thinking skills can be seen from the results of descriptive statistical analysis of the data which shows that groups of students who take learning using the STEM approach have an average score of critical thinking skills of 76.37 more than the average value of groups of students who take conventional learning which is 69.

Through the STEM approach students will have different ways of thinking and develop critical power and shape thinking logic, so that it can be applied in various sciences. In addition, students will get used to solving problems well. The teacher can package learning by utilizing the four fields of science in STEM to explain the subject matter of mathematics. Science is a body of knowledge that has accumulated from time to time from a scientific examination that produces new knowledge. Technology is the whole system of people and organizations, knowledge, processes and devices which then create objects and operate them. Engineering is a body of knowledge about the design and creation of man-made objects and a process for solving problems and Mathematics is the study of patterns and relationships between numbers, numbers, and space. By integrating the four disciplines, the students' critical thinking skills will increase.

### 3. Hypothesis III

The results of inferential statistics in the form of analysis of the third hypothesis test of data with the analysis of manova obtained the conclusion that H<sub>0</sub> is rejected and H<sub>1</sub> is accepted. The results of manova testing with the help of SPSS 22.0 for Windows are based on Pillai's Trace, Wilks Lambda, Hotelling's Trace, and Roy's Largest Root. In this test, obtained in column sig  $0.008 < 0.05$  then H<sub>0</sub> is rejected and H<sub>1</sub> is accepted. So, based on the results of the manova statistical analysis it was found that there was a simultaneous influence of learning with the STEM approach to the mathematical reasoning ability and critical thinking of class XI students of SMA Negeri 7 Denpasar in the academic year 2018/2019.

Learning with the STEM approach can arouse students' curiosity and trigger their creative imagination and critical thinking, help students to understand and experience the process of scientific inquiry, encourage collaboration on problem solving and interdependence in group work.

### **Conclusions**

Based on the results of the analysis and discussion, the following findings are obtained.

1. There is an effect of learning with the STEM approach to the critical thinking skills of class XI students of SMA Negeri 7 Denpasar in the 2018/2019 academic year.
2. There is an influence of learning with the STEM approach to the critical thinking skills of class XI students of SMA Negeri 7 Denpasar in the 2018/2019 academic year.



3. There is a simultaneous influence of learning with the STEM approach to the ability of mathematical reasoning and critical thinking of class XI students of SMA Negeri 7 Denpasar in the academic year 2018/2019.

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