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IMPROVE CRITICAL THINKING ABILITY AND MATHEMATICAL COMMUNICATION OF INFORMATION SYSTEMS STUDENTS WITH THE MISSOURI MATHEMATICS PROJECT (MMP) LEARNING

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ABSTRACT---*This study aims to improve the ability of critical thinking and mathematical communication of Information Systems students by learning the Missouri Mathematics Project (MMP). MMP is a program designed to assist lecturers in the effective use of exercises in the form of project worksheets so that students achieve improved learning outcomes. MMP emphasizes cooperative learning and student independence. The method used is a quasi-experimental method with a research design using pretest and posttest without randomization (Group Pretest-Posttest Design). The study population was Information Systems students at the Faculty of Engineering and Computer Science, Buana Perjuangan University, Karawang. Samples were taken as many as 2 classes, one class as an experimental class (MMP learning) and another class as a control class (conventional learning). The average scores of the two classes did not differ significantly, namely the critical thinking ability of MMP class students before learning 6.41 (32.05% of ideal scores) and conventional classes 5.84 (29.20% of ideal scores). The average score of the mathematical communication skills of the two classes did not differ significantly, namely the MMP class of 6.35 (31.75% of the ideal score) and the conventional class of 7.29 (36.45% of the ideal score). Pretest critical thinking and communication skills of the two classes are still not good when compared with the ideal score.*

Keywords---*Critical thinking, Mathematical communication, Missouri Mathematics Project*

I. Introduction

The ability to think critically in learning mathematics needs to be developed so that students have a tendency to be curious, as well as students trying to find all the information in solving a problem. In addition, critical thinking is an attempt to bridge the gap between problems taught in the classroom with problems in the field (the real world).

In learning mathematics, besides students must have critical thinking skills, the skills to communicate mathematical concepts and ideas also need to be developed. Mathematics as a language is not only a tool for thinking about finding patterns, solving problems and making decisions, but as a communication tool for conveying various ideas clearly, correctly and concisely. In addition, it is a vehicle for interaction between students as well as communication between lecturers and students.

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Based on the description above, critical thinking skills and mathematical communication are very important possessed by students to support success in learning mathematics. However, on campus, this ability is not sufficiently developed. Students are only able to answer the questions correctly but in communicating ideas, thoughts and ideas can not. Likewise with the ability to think critically mathematically students have still not been pursued. As a result, the independence of student learning becomes less.

Seeing these conditions, there needs to be efforts to improve critical thinking skills, mathematical communication, with supportive learning strategies. namely the Missouri Mathematics Learning Project (MMP).

II. Literature Review

Mulyana (2008) explains that the ability to think critically mathematically is the ability to think that is characterized by the ability to identify the assumptions given, the ability to formulate the main points of the problem, the ability to determine the consequences of a provision taken, the ability to detect the existence of biases based on different points of view, the ability reveal data / definitions / theorems in solving problems, and the ability to evaluate arguments that are relevant in solving problems.

Scriven and Paul (Syahbana, 2012) and Rohaeti (2010) define critical thinking as an intellectual disciplinary process that actively and skillfully conceptualizes, applies, analyzes, synthesizes, and / or evaluates information obtained from, or generated by observations, experiences, reflections , reasoning, or communication. Meanwhile Sumarmo (2012) explained that critical thinking is a complex concept involving cognitive skills and affective disposition. Next Fisher (2009) explains critical thinking as an active, persistent, and careful consideration of a belief or form of knowledge received.

Anggraeni and Sumarmo (2013) explain mathematical communication aimed at developing skills and confidence to use their own language, and mathematical language, as well as to express mathematical ideas. Furthermore, NCTM (Cotton, 2008) explains the communication process helps build meaning. When students are challenged to think and reason then communicate their ideas verbally and in writing.

III. Research Methodology

The method used is quasi-experimental research designs with pretest and posttest without randomization (Group Pretest-Posttest Design). This research was conducted on Information Systems students, FTIK Buana Perjuangan University, Karawang. Samples were taken by students in 2 classes. One class as an experimental class (MMP learning) and one class as a control class (conventional learning).

The following are the results of testing the instruments used in the research.

Table 3.1 Recapitulation of Test Results Analysis of Critical Thinking Ability Tests

No.	Validity Problem	Item of difference	Power of interpretation	Reliability	Interpretation
1	0,47 (moderate)	0,19 (moderate)	0,63 (moderate)	0,76	Problem used

2	0,86 (high)	0,44 (good)	0,69 (moderate)	(high)	Problem used
3	0,84 (high)	0,44 (good)	0,68 (moderate)		Problem used
4	0,83 (high)	0,53 (good)	0,68 (moderate)		Problem used
5	0,65 (high)	0,19 (cukup)	0,49 (moderate)		Problem used

Table 3.2 Recapitulation of Test Results of Mathematical Communication Ability Tests

No.	Validity Problem	Item of difference	Power of interpretation	Reliability	Interpretation
1	0,69 (high)	0,36 (good)	0,63 (moderate)	0,81 (very high)	Problem used
2	0,88 (high)	0,53 (good)	0,65 (moderate)		Problem used
3	0,79 (high)	0,58 (good)	0,51 (moderate)		Problem used
4	0,77 (high)	0,56 (good)	0,61 (moderate)		Problem used
5	0,79 (high)	0,44 (good)	0,42 (moderate)		Problem used

The instrument consists of 10 items consisting of 5 (five) items for the ability to think critically mathematically and 5 (five) items for mathematical communication skills and tested on 30 students.

IV. Results and Discussion

The class used in the study consisted of two classes chosen not randomly. Both classes consist of 29 students in the experimental class (MMP class) and 31 in the control class (conventional class). This study seeks to address the problem of increasing and achieving mathematical critical thinking skills, enhancing and achieving mathematical communication skills, the association between critical thinking skills and mathematical communication of students. These data were obtained from the results of the pretest and posttest.

The improvement of students 'critical thinking and mathematical communication skills in MMP and conventional classes is seen from the gain data which is reviewed based on the students' abilities. Whereas to find out the achievements and associations of students' critical thinking skills and mathematical communication in the MMP class and conventional class viewed from the posttest data. Processing of these data uses the Minitab 16 and Microsoft Excel 2010. Software applications are presented below with normalized pretest, posttest and n-gain descriptive data in the form of the following table.

Table 4.1 Data Description of Pretest, Posttest and N-gain Critical Thinking Ability and Mathematical Communication

Variable	Data Stat	Learning				
		MMP				
		N	*Pretest*	*%*	*Postest*	*%*
Critical Thinking Ability	$\overline{X}$	29	6,41	32,05	13,69	68,45
	SD		2,47		4,45	
Mathematical Communication	$\overline{X}$	29	6,35	31,75	14,38	71,90
	SD		1,78		2,51	
	Data	Konvensional				
Critical Thinking Ability	$\overline{X}$	n	*Pretest*	*%*	*Postest*	*%*
	SD	31	5,84	29,20	11,48	57,40
Mathematical Communication	$\overline{X}$		2,49		2,68	
	SD	31	7,29	36,45	12,84	64,20

Information :

Ideal Score for Critical Thinking: 20

Mathematical Communication Ideal Score: 20

Ideal Score for Learning Independence: 140

Pretest MMP Class and Conventional Class

Student pretest both MMP class student groups and conventional class student groups can be seen in table 4.2.

Table 4.2 Descriptive Statistics Pretest Score Critical Thinking Ability and Mathematical Communication

Variable	Data Stat	Learning					
		MMP			Konvensional		
		n	*Pretest*	% against the Ideal Score	n	*Pretest*	% against the Ideal Score
Critical Thinking Ability	$\bar{X}$	29	6,41	32,05	31	5,84	29,20
	SD		2,47			2,49	
Mathematical Communication	$\bar{X}$	29	6,35	31,75	31	7,29	36,45
	SD		1,78			1,87	

Information:

Ideal Score for Critical Mathematical Thinking: 20

Mathematical Communication Ideal Score: 20

Based on Table 4.2 that the average scores of the two classes are not significantly different, namely the critical thinking ability of MMP class students before learning is 6.41 (32.05% of the ideal score) and conventional classes are 5.84 (29.20% of the scores ideal). The average score of mathematical communication ability of the two classes did not differ significantly, namely MMP class 6.35 (31.75% of the ideal score) and conventional class was 7.29 (36.45% of the ideal score). Pretest critical thinking and communication skills of the two classes are still not good when compared with the ideal score.

a. Pretest Results of Critical Thinking Ability

Based on the results of the pretest critical mathematical thinking ability MMP class and conventional classes as in Table 4.3 below.

Table 4.3 Descriptive Statistics Pretest Score Students Critical Thinking Ability

Sample class	n	Skor Min	Skor Max	Mean	Std. Dev
Pem_*MMP*	29	2	14	6,41	2,47
Pem_Konvesional	31	2	11	5,84	2,49
Ideal score = 20					

Based on the data in table 4.3, that the initial ability to think critically MMP class students with conventional class students there are no significant differences, so that the analysis of the similarity of pretest results was tested. Before the average similarity test, the data distribution normality test and homgenity test were carried out.

Testing the normality of the distribution of pretest scores by means of the Kolmogrof-Smirnov statistical test using Minitab-16 Software obtained the following data.

Table 4.4 Test Results of Pretest Normality in Critical Thinking Ability

Sample class	N	Mean	Stdev	*p-Value*	Interpretation
MMP	29	6,41	2,47	p > 0,150	Normal distribution
Konv.	31	5,84	2,49	p > 0,150	Normal distribution

Based on the normality test, class results with MMP learning from the normality test obtained an average = 6.41 and a standard deviation = 2.47 from the number of students 29, and a p-value> 0.150 because the value of p≥0.05 then the data is normally distributed . While the conventional class obtained an average = 5.84 and standard deviation = 2.49 from the number of students 31, and p-value> 0.150, because the value of p ≥ 0.05 then the data is normally distributed. MMP class and conventional class are both normally distributed, then it is continued with the variance homogeneity test.

Testing the homogeneity of the pretest score variance for the critical thinking skills of the MMP class and the conventional class by means of the Kolmogrof-Smirnov statistical test obtained the following data:

$H_o : \sigma_1^2 = \sigma_2^2$: Population variance score of both homogeneous classes

$H_1 : \sigma_1^2 \neq \sigma_2^2$: Population variance score of the two classes is not homogeneous

Criteria :

p ≥ 0,05 : H_o is accepted

p < 0,05 : H_o is rejected

Table 4.5 Pretest Homogeneity Test Results Critical Thinking Ability

Sample class	MMP	conventional
N	29	31
Mean	6,414	5,839
StDev	2,472	2,491
p-Value	p = 0,970	
Interpretation	H_o is accepted	

Based on the variance homogeneity test obtained p = 0.970 meaning p> 0.05 so that the variance of both groups is homogeneous, because the variance of both groups is homogeneous, then for the significance test of the difference in the two average uses the t test as follows.

Hypothesis:

H_o : $\mu_1 = \mu_2$ there is no difference in students' critical thinking skills MMP class and conventional class before learning.

H_A : $\mu_1 \neq \mu_2$ there are differences in the critical thinking skills of MMP class students and conventional classes before learning.

Criteria :

$p \geq 0{,}05$: H_o is accepted

$p < 0{,}05$: H_o is rejected

Table 4.6 Test Results of Pretest Critical Thinking Ability

Sample class	N	Mean	Stdev	*p-Value*	Interpretation
MMP	29	6,41	2,47	*p* = 0,373	H_o is accepted
Konv	31	5,84	2,49		

Based on the significance test of the difference in the two average p = 0.373 means that p≥0.05 so accept Ho. In conclusion there is no difference in the critical thinking skills of MMP class students and conventional classes before learning.

b. Pretest Results of Mathematical Communication Skills

Berikut ini hasil pretest kemampuan komunikasi matematik:

Table 4.7 Descriptive Statistics Pretest Scores for Students' Mathematical Communication Skills

Sample class	n	Skor Min	Skor Max	Mean	Std. Dev
MMP	29	3	11	6,35	1,78
Konvensional	31	4	10	7,29	1,87
Ideal score = 20					

Based on Table 4.7, the initial ability of communication between students of the two classes there was no significant difference, so an analysis of the similarity test of the pretest results was conducted. Previously, the data distribution normality test and homogeneity test were conducted. Testing the normality of the distribution of pretest scores for class communication skills with MMP learning and conventional classes by means of the Kolmogrof-Smirnov statistical test.

The pretest normality test criteria for mathematical communication skills as follows.

$p \geq 0{,}05$: normal distribution data

$p < 0{,}05$: not normal distribution data

Table 4.8 Test Results for Mathematical Communication Pretest Normality

Sample class	N	Mean	Stdev	*p-Value*	Interpretation
MMP	29	6,35	1,78	p > 0,150	Normal distribution
Konv.	31	7,29	1,87	p > 0,150	Normal distribution

Based on the MMP class normality test results obtained an average = 6.35 and standard deviation = 1.78 from the number of students 31, and the p-value> 0.150 because the p value ≥ 0.05 then the data is normally distributed. While the conventional class obtained an average = 7.29 and standard deviation = 1.87 from the number of students 29, and p-value>0.150, because the value of p ≥ 0.05 then the data is normally distributed. Because the MMP class and the conventional class are both normally distributed, then it is continued with the variance homogeneity test.

Testing the homogeneity of the pretest score variance for the mathematical communication skills of the two learning classes by means of the Kolmogrof-Smirnov statistical test using data obtained:

$H_o : \sigma_1^2 = \sigma_2^2$: Population variance score of both homogeneous classes

$H_1 : \sigma_1^2 \neq \sigma_2^2$: Population variance score of the two classes is not homogeneous

Criteria :

p ≥ 0,05 : H_o is accepted

p < 0,05 : H_o is rejected

Table 4.9 Pretest Homogeneity Test Results Mathematical Communication Skills

Sample class	N	Mean	Stdev	*p-Value*	Interpretation
MMP	29	6,35	1,78	p = 0,802	H_o is accepted
Konv.	31	7,29	1,87		

Based on the variance homogeneity test obtained p = 0.802 meaning p> 0.05 so that the variance of both groups is homogeneous. Because the variance of the two groups is homogeneous, for the significance test of the difference in the two average uses the t test.

Hypothesis:

H_o : $\mu_1 = \mu_2$ there is no difference in mathematical communication skills of MMP class and conventional class before learning.

H_A : $\mu_1 \neq \mu_2$ there are differences in mathematical communication skills of MMP class and conventional classes before learning

Criteria :

p ≥ 0,05 : H_o is accepted

p < 0,05 : H_o is rejected

Table 4.10 t-Test Results Pretest Mathematical Communication Skills

Sample class	N	Mean	Stdev	*p-Value*	Interpretation
MMP	29	6,35	1,78	p = 0,049	H_o is accepted
Konv.	31	7,29	1,87		

Based on the test results of the significance of the difference in the two average p = 0.049 means that p <0.05 so that Ho rejects. It can be concluded that there are differences in mathematical communication skills of MMP classes and conventional classes before learning.

1. Achievement and Improvement of Critical Thinking Ability

a. Achievement of Critical Thinking Ability

Achievement of students' critical thinking skills using posttest data. Posttest normality test data of critical thinking ability was calculated by the Kolmogorof-Smirnov statistical test The statistical hypothesis tested was each of the posttest data of students who received MMP learning as an experimental class and students who obtained conventional learning as a control class

Table 4.11 Descriptive Statistics Postest Score Students Critical Thinking Ability

Sample class	N	Mean	Stdev	*p-Value*	Interpretation
MMP	29	6	20	13,69	4,45
Konvensional	31	6	16	11,48	2,68
Ideal Score = 20					

Based on the data in Table 4.11, the critical thinking ability of the students of the two learning classes did not have a significant difference, so an analysis of the similarity of posttest results was analyzed. Before the average similarity test, the data distribution normality test and homogeneity test are carried out.

Testing the normality of posttest score distribution for critical thinking skills of the two learning classes with the Kolmogrof-Smirnov statistical test obtained the following data.

Criteria:

p ≥ 0,05 : normal distribution data

p < 0,05 : not normal distribution data

Table 4.12 Test Results of Postt Normality in Critical Thinking Ability

Sample class	N	Mean	Stdev	*p-Value*	Interpretation
MMP	29	13,69	4,45	p > 0,150	Normal distribution
Konvensional	31	11,48	2,68	p > 0,150	Normal distribution

Based on the normality test post MMP class obtained an average = 13.69 and standard deviation = 4.45 from the number of students 29, and p-value> 0.150, because the value of p ≥ 0.05 then the data were normally distributed. While the results of conventional class posttest normality test obtained an average = 11.48 and standard deviation = 2.68 from the number of students 31, and p-value> 0.150, because the value of p ≥0.05 then the data is normally distributed. MMP and conventional classes are both normally distributed, then proceed with the homogeneity test of variance.

Testing the homogeneity of the posttest variance score scores in the mathematical critical thinking skills of the two classes with the Kolmogrof-Smirnov statistical test obtained the following data.

$H_o : \sigma_1^2 = \sigma_2^2$: Population variance score of both homogeneous classes

$H_1 : \sigma_1^2 \neq \sigma_2^2$: Population variance score of the two classes is not homogeneous

Criteria :

p ≥ 0,05 : H_o is accepted

p < 0,05 : H_o is rejected

Table 4.13 Results of Posttest Homogeneity Tests in Mathematical Critical Thinking Ability

Sample class	N	Mean	Stdev	*p-Value*	Interpretation
MMP	29	13,69	4,45	*p*= 0,008	H_o is rejected
Konvensional	31	11,48	2,68		

Based on the results of the variance homogeneity test obtained p = 0.008 meaning p <0.05 so that the variance of the two groups is not homogeneous, because the variance of the two groups is not homogeneous, then to test the significance of the difference between the two averages using the t 'Test as follows.

Hypothesis:

$H_o : \mu_1 = \mu_2$ achievement of the mathematical critical thinking ability of the MMP class is no better than the conventional class.

$H_A : \mu_1 > \mu_2$ achievement of the mathematical critical thinking ability of the MMP class is better than the conventional class.

Criteria :

p ≥ 0,05 : H_o is accepted

p < 0,05 : H_o is rejected

Table 4.14 Test Results t 'Postest Mathematical Critical Thinking Ability

Sample class	N	Mean	Stdev	*p-Value*	Interpretation
MMP	29	13,69	4,45	p=0,013	H_o is rejected
Konventional	31	11,48	2,68		

Based on the test results of the significance of the difference in the two average p = 0.013 means p <0.05, so reject Ho. It can be concluded that the achievement of mathematical critical thinking skills of MMP class students is better than conventional classes.

b. Increased Critical Thinking Ability

The improvement of students' mathematical critical thinking skills is obtained by processing normalized gain. Normalized N-gain score normality test was calculated by the Kolmogorof-Smirnov statistical test. The statistical hypothesis tested was from the pretest and posttest data of students who received MMP learning in the experimental class and students who obtained conventional learning in the control class.

Table 4.15 Descriptive Statistics N-Gain Score Critical Thinking Ability Mathematics

Sample class	n	Skor Min	Skor Max	Mean	Std. Dev
MMP	29	0,1	1	0,5	0,31
Konventional	31	0,2	0,7	0,4	0,22
Ideal score = 20					

Based on the data in Table 4.15, the mathematical critical thinking ability of MMP class students with conventional class students there is a significant difference, so an average similarity test analysis is performed. Before the average similarity test, the data distribution normality test and homogeneity test are performed first.

Testing the distribution normality for the mathematical critical thinking ability of MMP class and conventional class with the Kolmogrof-Smirnov statistical test obtained the following data:

Criteria:

$p \geq 0,05$: normal distribution data

$p < 0,05$: not normal distribution data

Table 4.16 N-Gain Normality Test Results Mathematical Critical Thinking Ability

Sample class	N	Mean	Stdev	*p-Value*	Interpretation
MMP	29	0,5	0,31	*p > 0,150*	Normal distribution
Konventional	31	0,4	0,22	*p > 0,150*	Normal distribution

Based on the MMP class normality test obtained an average of 0.5 and standard deviation = 0.31 of the number of students 29, and a value of P> 0.150 because the value of $p \geq 0.05$ then the data were normally distributed. While the conventional class obtained an average = 0.4 and standard deviation = 0.22 from the number of students 31, and P> 0.150, because the value of $p \geq 0.05$ then the data are normally distributed, because both the conventional class and MMP class are both distributed normal, then proceed with the test for homogeneity of variance.

Criteria:

$p \geq 0,05$: variance of both homogeneous groups

$p < 0,05$: variance of the two groups is not homogeneous

Table 4.17 N-Gain Homogeneity Test Results Mathematical Critical Thinking Ability

Sample class	N	Mean	Stdev	*p-Value*	Interpretation
MMP	29	0,5	0,31	p= 0,048	H_o is rejected
Konvensional	31	0,4	0,22		

Based on the variance homogeneity test obtained p = 0.048 meaning p <0.05 so that the variance of the two groups is not homogeneous, because the variance of the two groups is not homogeneous, then for the significance test of the difference in the two average uses the t 'Test as follows.

Hypothesis:

$H_o : \mu_1 = \mu_2$ which is an increase in the ability to think critically mathematical MMP class is not better than the conventional class.

$H_A : \mu_1 > \mu_2$ which is an increase in mathematical thinking ability of MMP class is better than conventional class.

Criteria :

$p \geq 0,05$: H_o is accepted

$p < 0,05$: H_o is rejected

After analysis, the following data are obtained:

Two-Sample T-Test and CI: Eksperimen; Kontrol

Two-sample T for Eksperimen vs Kontrol

	N	Mean	StDev	SE Mean
Eksperimen	29	1,47	1,45	0,27
Kontrol	31	0,404	0,177	0,032

Difference = mu (Eksperimen) - mu (Kontrol)

Estimate for difference: 1,069

95% lower bound for difference: 0,630

T-Test of difference = 0 (vs >): T-Value = 4,07 P-Value = 0,000 DF = 58

Both use Pooled StDev = 1,0177

(Sumber: Minitab 16)

Based on the results of the significance of the difference in the two average p = 0,000, it means that p <0.05 so that Ho reject It can be concluded that the increase in mathematical critical thinking skills in MMP class is better than conventional classes.

V. Recommendations

In further research, project worksheets can be improved such as variations of questions, or implemented in the field of computer technology.

VI. Conclusion

Based on the findings and discussion, this study provides the following conclusions.

1. The achievement and improvement of students 'mathematical critical thinking skills using Missouri Mathematics Project (MMP) learning is better than students' mathematical critical thinking abilities that use conventional learning.

2. The achievement and improvement of students 'mathematical communication skills with the defense of Missouri Mathematics Project (MMP) is better than students' mathematical communication skills with conventional learning.

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