The Improvement of Mathematical Communication Skill Through Project Based Learning with STEM Strategy

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Abstract---This study was conducted to determine the influence of Project Based Learning (PjBL) with science, technology, engineering, and mathematics (STEM) to improve students' mathematical communication skill (MCS) of seventh grade students in junior high school. This study was a quantitative research design. Population of this study were seventh grade students of SMP Negeri 12 Semarang and area random sampling used as a sampling technique selection.. The research subject were 32 students of Grade VII-G as experimental group which using PJBL with STEM strategy and 32 students of Grade VII-H as control group which using Discovery Learning model. Data was then analyzed using independent t-test, paired t-test and N-Gain test. The result of this study showed that learning process using PjBL with STEM strategy way more effective to improve MCS of the students which obtained that N-Gain diagrams by 0.703 in the high category, although there was not significant difference mean result both experiment and control group toward MCS. This PjBL with STEM strategy can be used in Indonesian learning process as well as for learning models that train MCS of the students especially for outdoor learning and 21st Century skill.

Keywords: Mathematical communication skill, Project Based Learning, STEM

I. INTRODUCTION

Education has important role to move in the world, seek better jobs and ultimately succeed especially in globalization era (Idris et.al, 2012). Effective education can provide the people with highly skilled human capital development process (MEDP 2013-2025 MOE, 2012). Communication is important skill which concerned in education and has a major role in the teaching and learning processes (Rawat, 2015; Wordu et.al, 2018). Communication is also one of five important skill that need to be owned by student in mathematical learning (NCTM, 2000) which was known as mathematical communication skills (MCS). Developing MCS in line with new paradigm of learning mathematics which is teachers not only tranferring knowledge and dominant in the classroom (Qohar, 2011). As an essential skill, MCS help students to connecting ideas to another ideas that must be mastered well by students (Paridjo & Waluya, 2017). MCS is important to help students provide answers and explanations related to mathematics problem (Purdavood & Wachira, 2015) and also improvement on the MCS is needed (Qohar & Sumarmo, 2013). Although there are many previous studies (Ferri, 2012; Rahman et.al, 2012; Isa & Burhanuddin, 2016; Vale & Barbosa, 2017) have shown the importance of MCS to students' learning outcomes, there are some barriers of enhancing MCS. The barriers experienced by students of seventh grade which students have difficulty to formulate given and asked information related to mathematical problem, associate concepts and formula to develop strategies in order to solve mathematical problem, presenting mathematical problem in the graphs, table, and algebraic form, use mathematical notation, and communicate the result and also draw conclusion. Most of students have not reach completeness limit of academic achievement.

As an essential skill, there is urgency to improve MCS of the students' in mathematical learning. Implementing learning model or media can be used as the solution. Project Based Learning (PjBL) with science, technology, engineering, and mathematics (STEM) is a learning model which applying problem–solving context related to real-world problems capture students' interest and provoke serious thinking as the students acquire which includes knowledge gain and sharing (Efstratia, 2014; Arantes do Amaral & Lino dos Santos, 2018) and they can response activities outside the school environment (Panasan & Nuangchalerm, 2010) to prepare and helping them in 21st century skills (Erdogan et.al, 2016). Furthermore, PjBL with STEM strategy facilities the students' understanding with regard to the higher order thinking skills and content learning. Therefore, this research was conducted to analysis the influence of improvement MCS for junior high school students using PjBL with STEM strategy.

II. METHODS

Research Design

This study was a quantitative research design. In this study there were two groups i.e., experimental group uses PJBL with STEM strategy and control group uses Discovery Learning model. During the learning process, experimental group used students' worksheet that integrates technology and engineering in science and mathematics learning content and also the internet and gadget as a tool to run the PjBL application to do the project given. The control group used power point and students' worksheet that did not integrate project with STEM strategy. Three times learning process carried out in the classroom in the subject of Arithmetic Social, both of experimental and control group.

Participants

This study was conducted in State Junior High School 12 Semarang, Indonesia. Area random sampling was done to selecting sample randomly from all of class VII in State Junior High School 12 Semarang with experimental group sample (VII-G) totaling 32 students and a control group (VII-H) with totaling subject of 32 students.

Research Instrument

The research instrument used in this study was MCS test (preliminary and post-test) which adapted by using indicators of NCTM 1989 and it was developed until give 5 indicators i.e., (1) students' ability to formulate given and asked information which related to mathematical problem; (2) students' ability to associate mathematical concepts or formula to develop strategies (3) students' ability to present mathematical problem into form tables, graphs, or algebra and vice versa; (4) students' ability to use mathematical symbols and notation and also mathematical number operations in order to solve mathematical problem; (5) students' ability to communicate the answer of given mathematical problem and draw conclusion. The MCS test consisted of 8 description questions (essay) have been validated by experts and tested empirically. The result of the analysis can be seen in Table 1.

Table 1. Analytical Results of Empirical Trial MCS Test

	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8
Rxy table	0.3673							
Validity (Rxy)	0.57	0.364	0.67	0.77	0.69	0.74	0.75	0.77
Reliability ($\sigma_i{}^2$)	9.329	14.18	32.63	20.48	11.005	15.35	15.71	25.31
r_{11}	0.8212							
Level of difficulty	0.7327	0.6258	0.5172	0.5413	0.37758	0.337	0.246	0.3
Different power	0.2	0.1105	0.5425	0.3675	0.2585	0.3685	0.3875	0.451

The interpretation of the above analysis showed result for reliability test was $r_{11} = 0.8212 > 0.3673 = r_{xy}\ table$ which mean test result was reliable with high category. Validity test for item number 2 has validity $(r_{xy}) < 0.367$ which mean that item number 2 was not valid. The result of different power analysis obtained that items number 1 and number 2 had INDEX≤ 0.2, and item number 1 and 2 was not suitable of fit with PjBL using STEM strategy cannot be used in the field of trials. Thus, MCS test used in this study were only six items descriptive questions.

Analysis of Data

The Gain standard used to analysis of increase in MCS test. In this study, Gain standard values interpreted according to the Table 2.

$$Std.\,gain < g \geq \frac{\bar{X}_{postest} - \bar{X}_{preliminarytest}}{X - \bar{X}_{preliminarytest}}$$

Table 2. Standard Gain Criteria of the Study

G-value	Category
$G < 0.3$	Low
$0.3 \leq G < 0.7$	Medium
$G \leq 0.7$	High

The Independent and Paired t-test was carried out using *Statistical Package for the Social Sciences* (SPSS) 21.0. Independent t-test or two sample t-test is an inferential statistical test to determine the difference between the means of two unrelated groups (experimental and control group) while paired t-test or dependent t-test is comparative test to determine the difference means of related group (preliminary and posttest of experimental group) (Sukestiyarno, 2015). The t-test can be done if it is fulfilling two conditions namely normality and homogeneity test. The t-test in this study using sig. level 5% and decision criteria is H_0 rejected if sig. < 0.05.

Analysis of effect size was done to determine contribution learning of this study uses PjBL with STEM strategy to improving of MCS. There were two stages to effect size analysis namely to find the

influence of learning with PjBL using STEM strategy towards dependent variable of mathematical communication and separately analysis using preliminary and post-test of MCS test in both experimental and control group. Cohen's equation below was then used to calculate Cohen's d of effect size analysis. Cohen's d category in this study divided into four categories namely $0 < d \leq 0.20$ interpret as weak effect, $0.20 < d \leq 0.50$ interpret as modest effect, $0.50 < d \leq 1.00$ interpret as moderate effect, and $d > 1.00$ interpret as strong effect.

III. RESULTS AND DISCUSSION

Students' worksheet (LKPD) with STEM approach and project integrated STEM as learning medium uses in experimental group while control group using commonly learning strategies (Discovery Learning model) by teacher and not integrated with STEM.

Result of Mathematical Communication Skill (MCS)

Based on the result of students preliminary test in experimental and control group are in the same starting point (see Fig. 1) which means that students' initial skill has the same skill of mathematical communication and also there is no significant difference between initial ability of control and experimental group. In the posttest result, improvement on the MCS happen on the both experimental and control group (see Table 3 and Fig. 1). However, improvement on the MCS using PjBL with STEM strategy higher then MCS using Discovery Learning model, it provided by the result of mean gain of experimental group categorized as high category while mean gain of control group categorized as medium category. This provides that PjBL with STEM strategy is more effective to improve MCS than using Discovery Learning model, although there is no significant different between two groups. PjBL with STEM strategy also providing students with more realistic problem experience related to technology and engineering in the form of science and mathematics content's problem and also enhancing students' interaction, collaboration,

communication, and independency to solve project given. Learning with PjBL using STEM strategy can therefore improve the students' MCS. These result are relevant to those of the previous research studies (Baran & Bazkan, 2010; Olivarez, 2012; Meng et.al, 2013) which state that learning process with PJBL integrated STEM impacted students' academic achievement.

Results of MCS in control and experimental group are presented in Table 3 and Fig. 1.

Table 3. MCS Test Results

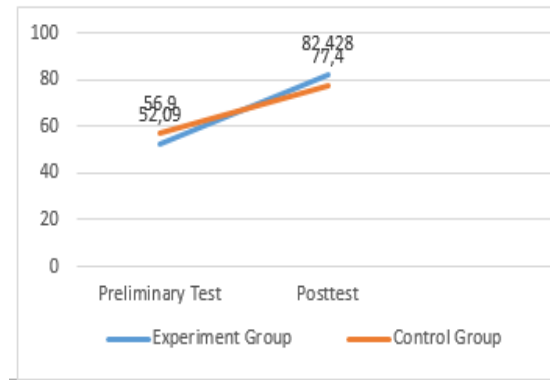| Class	Experimental	Control
N	32	32
Preliminary Result Mean	52.09	56.9
Posttest Result Mean	82.428	77.44
N-Gain Value	0.703	0.428
Category	High	Medium

Figure 1. Graph Improvement Result of MCS Mean Score

The t-test on this study used to analysis the difference between experimental group that uses PjBL with STEM strategy and control group that uses Discovery Learning model (independent t-test) and the difference between preliminary and posttest that uses PjBL with STEM strategy (dependent t-test). As a requirement of t-test, normality and homogeneity test was then analyzed with the test result as follows.

Table 4. Normality and Homogeneity Test Results

Normality Test					
Mathematical Communication Skill (MCS)	Class	Kolmogorov-Smirnov Test			
		N	Kolmogorov-Smirnov Z		Sig. (2-tailed)
	Experimental	32	0.747		0.631
	Control	32	0.857		0.455
Homogeneity Test					
	Class	Mean	Std. Dev	F_{hitung}	F_{table}
Mathematical Communication Skill (MCS)	Experimental	82.42	8.8		
	Control	77.44	9.78	1,23	1,82

Based on the Table 4, obtained that sig. (2-tailed) > 0.05 (*level of significant*) which mean H_0 rejected and data are normally distribute and the homogeneity test (see Table 4) obtained that $F_{hitung} <$ F_{table} which mean data are homogeneous. Since data normally distributed and homogeneous, independent and paired t-test was then used to determine the difference mean of the data.

Table 5. Classical Completeness Limit on the MCS Result Test

Classical Completeness Limit of Posttest MCS Test Result of Experimental Group					
Posttest of Experimental Group	x	n	π_0	z_{table}	z_{test}
	29	32	0.75	1,64	2.09
Classical Completeness Limit of Posttest MCS Test Result of Experimental and ControlGroup					
Class	x	n	p	q	z_{table} z_{test}
Experimental Group	29	32	0.828	0.171	1.64 1.656
Control Group	24	32			

Based on the Table 5, obtained that from MCS test result of experiment group is $z_{test} = 2.09 > 1.64 = z_{table}$ which mean that H_0 rejected and H_1 accepted. Therefore, students percentage of sample class uses PjBL with STEM strategy reaches completeness limit classically which is 75%. Also, based on the Table 5 obtained that posttest of experiment and control group is $z_{test} = 1.656 > 1.64 = z_{table}$ which mean that H_0 rejected and H_1 accepte. Therefore, student proportion that reaches completeness limit uses PjBL with STEM strategy greater than student proportion that reaches completeness limit uses Discovery Learning model. Then, independent t-test was done on this study to measure wheater means of experimental group which uses PjBL with STEM strategy equal or unequal to control group which uses Discovery Learning model can be seen on the Table 6.

Table 6. Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	df	Sig. (2-tailed)	Std. Error Difference
class	Equal Variances assumed	0.142	0.708	2.112	62	0.039	2.324
	Equal variances not assumed			2.112	61.362	0.039	2.324

Based on the Table 6, result of Levene's Test for Equality of Variances obtained that p-values is 0.708, so the assumption of equal variances is not violated. The value of t-statistic is 2.112 and the p-value is 0.039 which mean H_0 formally rejected. Thus, there is difference between experimental group taught using PjBL with STEM strategy and control group taught using Discovery Learning model. It was concluded that there were significant difference of students' MCS to the control and experiment group.

Paired t-test on this study was done to determine whether there is difference to the preliminary and posttest of experimental group. The analysis result of the test can be seen on the Table 7.

Table 7. Paired Sample Test

	Std. Dev	Std. Error Mean	t	df	Sig. (2-tailed)
Pair 1 pre & post	11.9694	2.115	12.017	31	0.0000

Based on Table 7, obtained that sig. (2-tailed) is 0.000<0.05, then H_0 rejected. Thus, there was significant difference between of MCS preliminary test and MCS posttest. It was concluded that PjBL with STEM strategy influence the improvement of academic achievement related to MCS of the students.

Analysis of Effect Size

After it was known that PjBL with STEM strategy influences MCS of the students, an analysis was conducted to find out how much influence it has based on dependent variables involving the preliminary and posttest both control and experiment group. The result of analysis of effect size can be seen on the Table 8.

Table 8. Analysis of the effect of learning (Cohen's d)

		N	Mean	Std. Deviation	d	Category
Experiment	post	32	82.4281	8.80748	8.778	Strong
	pre	31	56.9032	13.80424		
Control	post	32	77.5219	9.75608	7.929	Strong
	pre	32	52.0938	15.29571		

Based on Table 8, it is known information that the application of PjBL with STEM strategy in experimental group has a "strong" effect on students' MCS with d-value is 8.778 > 1.00 while control group which using Discovery Learning model has also "strong" effect on students' MCS with d-value is 7.929 > 1.00. Based on this data, it can be concluded that there is no significant difference in the effect of learning using PjBL with STEM strategy and Discovery Learning model in improving MCS of the students. However, the effect given by PjBL with STEM strategy greater and better than Discovery Learning model because of d-value of experimental group is 8.778 >7.929.

These findings are aligned with several other studies that indicate that implementing an innovative instruction showed positive growth across student stakeholders (Han, et.al, 2014). Consistency and fidelity of implementation have been important factors in assessing the merits of any innovation (in this case project based learning integrated STEM) cause it is needed to examine full implementations over other possible cases and a teacher needed to do new things and to re-conceptualize (Cakici & Turkmen, 2013; Erdogan et.al, 2016). Implementing project based learning increases students' academic achievement and authentic problem-solving on behalf of the experimental group (Kizkapan & Bektas, 2017). Positive effect and statistically significant difference occur between experimental and control group through project based learning integrated STEM and were pointed out to improve student' academic achievement (Baran & Bazkan, 2010). In line with this statement Han, et.al (2015) stated that project based learning integrated STEM in learning is able to improve students' mathematical achievements in various group of abilities both high, medium and low. Because of positive influence on the student achievement learning occur when implementing project based learning integrated STEM (Erdogan et.al, 2016). Project based learning integrated STEM also indicated that it can help students' problem solving performance more than conventional teaching instruction (Psycharis, 2013). In line with that statement, mathematical communication ability through project based learning integrated STEM better than using conventional learning model (Ambarwati et.al, 2015).

IV. CONCLUSION

The result of this study indicate there were significant difference between students who were taught using PjBL with STEM strategy and the counterparts by Discovery Learning model, both on the parameters of the student academics achievement and MCS. Moreover, although there was not significant difference both experiment and control group, PjBL with STEM strategy has had the potential to enhancing students' learning outcome related to MCS. The suggestion of this study is teacher can use PjBL with STEM strategy as an alternative model learning which relevant to the 21st Century learning. For the future research, need to develop learning assessment of the implementation PjBL with STEM strategy in order to find positive influence of the model intensively and thoroughly and also long-term impact of PjBL with STEM strategy must be analyzed.

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