THE EFFECT OF PROBLEM BASED LEARNING (PBL) COMBINED WITH COOPERATVE LEARNING JIGSAW IN TERMS OF MATHEMATICAL COMMUNICATION SKILL AND STUDENT'S ACHIEVEMENT GRADE 11TH SCIENCE SMA N 2 YOGYAKARTA

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Abstract

The aim of this study was to know about the effect of Problem Based Learning (PBL) combined with cooperative learning Jigsaw in terms of mathematical communication skill and student's achievement in mathematics grade 11th Science SMA Negeri 2 Yogyakarta. The research method is quasi experiment which used one experiment group and one control group. The data were collected through a mathematical communication and student's achievement tests, questionnaire for oral communication in mathematics learning, and observation form for learning activities and student's communication. The results of the study showed that (1) PBL-Jigsaw is not better than scientific approach in student's mathematical communication skill, (2) PBL-Jigsaw is not better than scientific approach in student's achievement, and (3) there was a significant correlation, 0.618, between mathematical communication skills and student's achievement.

Keywords: PBL, Jigsaw, scientific, mathematical communication, student's achievement.

INTRODUCTION

Mathematics is a basic knowledge of the science and technology development. So that mathematics is one of the lessons in formal education which must be learnt in each education level in Indonesia.

Communication is an important part of mathematics education. "Communication is an essential part of mathematics and mathematics education that is a way of sharing ideas and clarifying understanding" (NCTM, 2000: 75). While Dwi Siswoyo (2008) states that communication is the way to share ideas and to get a mathematics understanding. Basically, education is a process of communication that consists of transformation of knowledge, values, and skills. If there is no communication in mathematics learning, then the ideas of mathematics could not be transfer well. So the mathematical communication skill is the skill that people communicates a message to the other. The message could be mathematics concepts or mathematics ideas in systematically and clearly.

Mathematical communication skill is an important aspect that student should has. While Wahid Umar (2012), the journal of "*Membangun Komunikasi Matematis dalam Pembelajaran Matematika*", states two reasons of mathematical communication needed in mathematics learning. First, mathematics is a language because mathematics is not only a tool in solving problem. But mathematics is an activity to communicate the ideas systematically and clearly. Second, mathematics is a social activity because every student does an interaction with his friends and also his teacher. But the situation in SMA N 2 Yogyakarta did not show a communication activity of their work. Students used work individually without get a chance to communicate it to the other, personally or group. So the ability in mathematical communication of mostly students in that school is less.

Student's achievement has a connection with cognitive ability because learning is always based on cognition. While W. S. Winkel (2004) states that student's achievement is a result of students who did a learning activity in school and also an effort to get a change of their knowledge, attitude, and behavior. So student's mathematics achievement is a result of all active activities that has been did along the mathematics learning process and also get interaction with their social environment and mathematical objects so they could develop their knowledge and skills. The mathematical objects are not only to understand and examined, but also use as a tool to solve a problem.

Mathematical communication connected to the student's achievement. NCTM (2000: 60) states that communication is an essential part of mathematics and mathematics education that is a way of sharing ideas and clarifying understanding. In other, NCTM (2000: 268) also states that communication is an essential feature as students express the results of their thinking orally and in writing. Because of thinking, reasoning, and understanding of mathematics express through communication orally an writing, then the mathematical communication skill that someone has could affect their achievement in mathematics.

Based on the observation in grade 11^{th} science SMA N 2 Yogyakarta, the active mathematics learning was not seen. Some students followed the activity actively and criticize the teacher's explanation, but the other was passive during the learning process. There are some problems in mathematics learning in grade 11^{th} science SMA N 2 Yogyakarta, such as a) students was depend on teacher's explanation about the material although he has try a cooperative learning, b) the problems were not challenge the students so they got bored, c) students worked individually in the group activity and could not explain well to their friends about some concept, and d) many students did a mistake to solve a mathematics problem according to their work during the learning process. So the innovative learning methods need in learning process to support and maximize the students' ability.

Based on the problems that explained above, the learning process need a learning methods or model which help students to develop their mathematical communication and student's achievement. One of the learning models is Problem Based Learning (PBL) combined with cooperative Jigsaw. Actually, the models could motivate students to be more active. Piaget states that students are learning and experiencing by himself and directly involve in realistic with the objects (Sugihartono, et. al, 2007: 109). The direct learning could stimulate their curiosity, critical thinking, problem solving, etc. The learning model that focuses on problem solving is Problem Based Learning (PBL). Muhamad Farhan (2014: 238) states the characteristics of PBL, such as real problem; students use various sources and information; students focus to discuss and investigate to solve problems in group; helping students to evaluate the problem solving. The research by Muhamad Farhan (2014: 239) shown that PBL effective to increase student's achievement, representation, and their motivation. Besides that, the research by Nurina Happy (2014) also shown that PBL effective in term of mathematical thinking.

Besides that, Vygotsky states that learning is an activity which did in interaction with their social and physic environment. Learning process need an interaction with the other people, between students and teacher, students and students. The learning model which facilitates them is cooperative learning, such as Jigsaw. PBL, which uses contextual problem in learning, and Jigsaw, which gives a priority to group learning, could help students to develop their mathematical communication and student's mathematics achievement.

Problem Based Learning (PBL) combined with cooperative Jigsaw is a learning model which combines the learning process based on problem and cooperative. Students gave a problem to solve in expert group and share the solution to the other friends in home group. So the problems are solved by students cooperatively. The steps of PBL combined with cooperative Jigsaw as following:

a. students get some various problems to solve.
b. organize students into small groups that consist of 4 students as called home group.
c. students find their friends who have the same problem and make a group as called expert group.
d. students in expert group identify the given information to solve the problem by using their previous concept.
e. students discuss and find the solution of the problems.
f. students back to the home group to share or present their work in expert group before.

The steps of Problem Based Learning combined with cooperative Jigsaw was formed from the steps of the two learning models, PBL and Jigsaw. In the end, students could get two benefit, those are problem solving and social, through this model. The journal of *"Pengaruh Pembelajaran Berbasis Masalah Dengan Setting Kooperatif Jigsaw Terhadap Kemampuan Komunikasi Matematis Serta Kemandirian Belajar Siswa SMA"* by Asep Ikin Sugandi and Utari Sumarmo (2010) informed that the results of the effect of Problem Based Learning combined with cooperative Jigsaw in term of mathematical communication. The result was shown that PBL-Jigsaw had a role to the mathematical communication achievement.

RESEARCH METHOD

Types of Research Method

This study was a quasi-experimental research. The research design was *pre-test post-test group design*.

Table 1. Design *pre-test post-test group design*

	Pre-test	*Treatment*	*Post-test*
Control	O1	X1	O2
Experiment	O1	X2	O2

Time and Place

This research did at SMA N 2 Yogyakarta on March 20th to April 17th 2015.

Population and Sample

The population in this research was the students of grade 11th science SMA N 2 Yogyakarta period year 2014/2015. The samples were students of class XI PMIIA 4 as the experiment class and XI PMIIA 4 as the control class. The sample had been chosen randomized.

Variables

The variables were consisted of independent variable, dependent variable, and control variable. The independent variables were the learning methods; they were Problem Based Learning (PBL) combined with cooperative Jigsaw and scientific approach. The dependent variables were mathematical communication and student's mathematics achievement. The control variables were teacher, material, and allocation time of learning.

Data, Instrument, and Data Collection Techniques

The instruments in this study were the test instrument of mathematical communication and student's achievement, questionnaire of oral communication, and observation form of learning activities and student's communication. The tests were pre-test and post-test about mathematical communication and student's achievement that given before and after the treatment. The questionnaire was given after the treatment.

Data Analysis Techniques

The data that used in statistics analysis was pre-test and post-test data. Data analysis of hypothesis one and two used *t*-test to the average of gain score of post-test and pre-test. The hypothesis was

$$H_0: \mu_1 \leq \mu_2$$
$$H_1: \mu_1 > \mu_2$$

as μ_1 was the average of gain score of post-test and pre-test experiment class and μ_2 the average of gain score of post-test and pre-test control class. Gain score calculated by using the formula

$$Skor\ gain\ (g) = \frac{x_2 - x_1}{x_{maks} - x_1}$$

Notes:

x_1: pre-test score of mathematical communication or student's achievement

x_2: post-test score of mathematical communication or student's achievement

x_{maks}: maximum score of mathematical communication or student's achievement

T-test used to analyze the data.

$$t = \frac{\bar{x}_1 - \bar{x}_2}{s_{gab}\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

as $v = n_1 + n_2 - 2$ and

$$s_{gab} = \sqrt{\frac{(n_1 - 1)s^2{}_1 + (n_2 - 1)s^2{}_2}{n_1 + n_2 - 2}}$$

Notes:

$\bar{x}_1$: the average of gain score of post-test and pre-test experiment class

$\bar{x}_2$: the average of gain score of post-test and pre-test control class

n_1 : the amount of students in experiment class

n_2 : the amount of students in control class

s_{gab} : total of standard deviation

The level of significant is $\propto = 0{,}05$. The criteria of H_0 is rejected if *p-value (sig)* $< \propto$ or $t > t_{table} = 1{,}67$.

Data analysis for the third hypothesis testing used *t*-test to the post-test score of mathematical communication and student's mathematics achievement of the two classes. *T*-test used to know the correlation between mathematical communication and student's achievement. The hypothesis was

H_0: $\rho = 0$ (there is no correlation between mathematical communication and student's mathematics achievement).

H_1: $\rho \neq 0$ (there is correlation between mathematical communication and student's mathematics achievement).

The formula was

$$t = \frac{r}{\sqrt{\frac{1-r^2}{n-2}}}$$

Notes:

r: correlation coefficient

$$r = \frac{n\Sigma xy - (\Sigma x)(\Sigma y)}{\sqrt{n\Sigma x^2 - (\Sigma x)^2}\sqrt{n\Sigma y^2 - (\Sigma y)^2}}$$

x: post-test score of mathematical communication of experiment and control class

y: post-test score of student's achievement of experiment and control class

n: the total of experiment and control class students

The criteria of H_0 was rejected if $t > t_{table} = 1{,}998$ dan $t < -t_{table} = -1{,}998$ with the level of significant was 0.05.

RESULTS AND DISCUSSION

The averages of student's achievement of experiment and control class were increase after the treatment. The data of student's mathematics achievement test are shown in Table 2.

Table 2. The data of student's mathematics achievement

Statistics Description	Experiment		Control	
	Pre-test	Post-test	Pre-test	Post-test
Mean	64,43	68,62	65,63	73,58
Varians	61,14	159,09	62,68	101,65
Max Score	78,75	91	78,75	87
Min Score	41,25	43	46,25	49

Table 2 shown that the average of pre-test and post-test score of student's mathematics achievement of experiment class were lower than control class.

The averages of mathematical communication of experiment and control class were also increase after the treatment. The datas of mathematical communication test are shown in Table 3.

Table 3. The data of mathematical communication

Statistics Description	Experiment		Control	
	Pre-test	Post-test	Pre-test	Post-test
Mean	20,62	62,65	18,10	76,47
Varians	148,73	294,90	149,56	219,12
Max Score	41	97	41	97
Min Score	0	33	0	42

Table 3 showed the average of pre-test score of mathematical communication in experiment class was higher than control class. It was different from the average of post-test score of mathematical communication in experiment class was lower than control class.

The questionnaire score of each aspect of oral communication explained in Table 4.

Table 4. The questionnaire score of oral communication

Oral Communica-tion Aspect	Percentage of Aspect Score (%)	
	Experiment	Control
A	79,41 (High)	69,96 (Medium)
B	71,32 (Medium)	70,70 (Medium)
C	72,79 (High)	75,54 (High)

Notes:

A: the ability of expressing the mathematical ideas orally and demonstrate, also describe it visually.

B: the ability of understanding, interpreting, and evaluating the mathematical ideas orally, or visually.

C: the ability to use the terms, mathematics notations, and its structures to present the ideas, also describe the relation to the mode situation.

Table 4 showed the percentage of each aspect of oral communication in experiment and control class was in category medium to high.

Hypothesis testing did after normality and homogeneity test. Normality test did to know the data normally distributed or not. If the significant was less than 0.05, then H_0 rejected.

Table 5. Normality test

Class	Test	Normality Test (Kolmogrov-Smirnov)		Conclu-sion
		Sig.	Interpreta-tion	
Experi-ment	*Pre-test* mathemati-cal communica-tion	0,057	H_0 not rejected	Normal
	Pre-test student's mathematics achievement	0,200	H_0 not rejected	Normal
Control	*Pre-test* mathemati-cal communica-tion	0,110	H_0 not rejected	Normal
	Pre-test student's mathematics achievement	0,200	H_0 not rejected	Normal

Table 5 showed the signification of pre-test and post-test score of mathematical communication and student's mathematics achievement in experiment and control class were greater than 0.05. So that the conclusion was the population normally distributed.

Homogeneity test did to know the classes had the same variance or not. If $f \leq f_{\text{table}} = 1.82$, then H_0 rejected.

Table 6. Homogeneity test

Test	f	f_{table}	Interpretation	Conclusion
Pre-test mathe-matical commu-nication	0,99	1,82	H_0 not rejected	Homogen
Pre-test student's mathe-matics achieve-ment	0,98	1,82	H_0 not rejected	Homogen

Table 6 showed the variance of pre-test and post-test score of mathematical communication and student's mathematics achievement in experiment and control class were same. After normality and homogeneity test, then continued to the hypothesis test.

Learning by using Problem Based Learning (PBL) combined with cooperative Jigsaw in term of mathematical communication

The results by using the average of gain score shown that $t = -4{,}89 < t_{table} = 1{,}67$. It

was concluded that learning by using PBL-Jigsaw is not better than learning by using scientific approach in term of student's mathematical communication.

NCTM (2000: 60) states that communication is an essential part of mathematics and mathematics education that is a way of sharing ideas and clarifying understanding. Based on the concept of communication, learning process is a functional communication process between students and teacher, and students and students in their attitude and thinking that would be students' behavior (Erman H. Suherman, 2001: 9). So the mathematical communication skill is the skill that people has in communicated a message to the other. The message could be concepts or mathematics ideas in systematically and clearly.

There is a communication step in the steps of PBL-Jigsaw. Also the scientific approach has the learning steps, such as observing, asking question, associating, experimenting, and communicating. There is a competency for each steps of scientific approach. The competency in communication is students could develop their communication as well as (Kemendikbud, 2014: 28). The Problem Based Learning has a different competency which is focusing on cognitive skill. While Kemendikbud (2014: 40) states that the aim and learning results of Problem Based Learning is thinking and problem solving skill. Based on the explanation, scientific approach has an explicit aim of communication development rather than PBL.

It was supported by research of Nugroho Widi P. about "*Pengaruh Pembelajaran dengan Pendekatan Scientific Berbantuan Software Geometer's Sketchpad terhadap Peningkatan Pemahaman dan Komunikasi Matematis serta Self-Confidence Siswa SMP*". This research shown that the scientific approach was increased the student's mathematical communication.

Learning by using Problem Based Learning (PBL) combined with cooperative Jigsaw in term of student's mathematics achievement

The results by using the average of gain score shown that $t = -2{,}88 < t_{table} = 1{,}67$. It was concluded that learning by using PBL-Jigsaw is not better than learning by using scientific approach in term of student's mathematics achievement.

Student's achievement has a relation to the cognitive ability because learning is always based on cognition. While Maya Kusumaningrum dan Abdul Aziz Saefudin (2012: 571) stated that students develop their high order thinking of problem solving in mathematics. This ability uses student's cognition in solving a problem.

Johari Marjan (2014) stated that scientific approach is a learning which focusing on inquiry learning theoretically. It has relation to the science nature and science attitude to do it. The science attitudes consist of observing, asking, collecting information, associating, and communicating. The systematical science attitudes could help students to systematical problem solving and radical thinking that would be affecting into their achievement.

PBL-Jigsaw learning focus on solving a problem that gives a learning experience, such as making hypothesis, investigation, collecting information, making conclusion and discussing, and presenting the results in group. The difference between PBL-Jigsaw and scientific is group discussion. But the weakness of group discussion is only one student who would be active; students could not be responsible to their work and copying for their friend's work. Because of students was copying their friends' work, then they were not understood what they do and write. When they explain it to the other in the home group, they were not understood and the other did not get maximal information. So the scientist attitude of collecting information and solving problem systematically and clearly do not has in all students. It would be affect to their achievement. This is also proving by analysis

results of the individual score that shown that PBL-Jigsaw is not better than scientific approach.

It was supported by research of Ermawati about "*Pengaruh Penerapan Pembelajaran Berbasis Pendekatan Scientific terhadap Prestasi Belajar Siswa pada Mata Pelajaran Matematika Kelas VII di SMP N 1 Margahayu*". This research showed that the scientific approach was a significant effect to the student's achievement in mathematics class VII SMPN 1 Margahayu.

The correlation between mathematical communication and student's achievement by using Problem Based Learning (PBL) combined with cooperative Jigsaw

According to the analysis results, it shown that $t = 6{,}79 > 1{,}998$. It was concluded that there is a correlation between mathematical communication and student's mathematics achievement. It means that if the mathematical communication score increased, then the student's mathematics achievement would be increased too.

NCTM (2000: 268) also states that communication is an essential feature as students express the results of their thinking orally and in writing. Because of a thinking, reasoning, and understanding of mathematics express through communication orally and writing. Thinking and reasoning were on the cognitive aspect of student. This cognitive would be determining the student's achievement. If the student's mathematical communication was good, then his mathematics understanding was also good. So it would be increased their achievement.

It was supported by research of Arvina, et al about "*Pengaruh Komunikasi Matematis terhadap Prestasi Belajar Matematika Siswa Kelas VIII di Kecamatan Purwodadi*". This research showed a positive correlation between mathematical communication and student's mathematics achievement. So the mathematical communication has an effect to the student's achievement in mathematics.

CONCLUSION AND RECOMMENDATION

Conclusion

Based on the results of this research, it can be concluded: (1) the learning by using PBL-Jigsaw was not better than learning by using scientific approach in term of mathematical communication skill, (2) the learning by using PBL-Jigsaw was not better than learning by using scientific approach in term of student's achievement, (3) there was a significant correlation, 0.618, between mathematical communication skill and student's mathematics achievement.

Recommendation

For students, do a discussion with his members group and not always ask teacher, and also following the learning activity well in group discussion.

For school, to develop and implementing any learning models or methods in mathematics learning to increase the mathematical communication and student's achievement, such as PBL-Jigsaw could be an alternative of learning to increase the mathematical communication and student's achievement.

For other researcher, try to add another variable or compared PBL-Jigsaw and the other learning model to get the results better.

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