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The Improvement of Mathematical Problem-solving through the Application of Problem Posing & Solving (PPS) Learning Model

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***Abstract*—Problem solving is an integral part of the learning process especially in mathematics and plays an important role because most of the learning is part of the problem-solving process; therefore, the problem solving is not only as a learning objective but also as a way to conduct the learning process. In fact, the mathematics learning process in schools gives less chance for students to solve problems in developing their ability. It is indicated by the result of the study evaluation particularly in the mathematics problem-solving test, which was still uneven and categorized as in low category. The low ability of mathematical problem solving requires innovations in the mathematics learning process. One of which is the implementation of Problem Posing and solving (PPS) learning model, this model allows students to connect their knowledge with their experiences or real-world concepts so that it creates a better conceptual understanding and ultimately motivates them to study. This study scientifically aims at encouraging students' thinking ability in order to improve their mathematical problem-solving ability in junior high school. This study is a quasi-experimental design with two experimental classes without any control class. The data collecting method is used to measure students' mathematical problem-solving abilities using test instruments. From the result of the Wilcoxon test, it was obtained that the result of the two experimental classes as p <0.05 and the first class N-gain was 0.47 increased to 0.52 in the second-class test. The effect size test from 2.207 in the first class test became 2.272 in the second or both class tests, which is included in the big effect category. It means that the implementation of the PPS learning model is effective in improving students' mathematical problem-solving ability.**

***Keywords*—learning model, problem posing, problem-solving**

I. Introduction

Mathematics is often considered as knowledge, which is only emphasized on logical thinking with a single and exact answer. It makes mathematic horrible and shunned subject, in spite of the fact that math is studied in all levels of education and becomes an indicator of student success in having education, and one of the material for selecting employees in the certain field. Considering this condition, it means that mathematics is not only used as the consideration to continue to the next level of education but also it can support career promotion.

Competition in the world never stops; therefore all individuals are required to create new ideas as an alternative solution to solve the encountered problem. Problem-solving is one of the abilities in the mathematics curriculum that helps students in applying, integrating concepts, mathematical skills and making decisions in developing conceptual understanding [1][2][3][4]. It is in accordance with the statement of Ersoy [5] which stated that problem-solving is an integral part in the learning process particularly in mathematics and plays a very important role because almost all of the learning process is the result of the problem-solving. Therefore the problem solving is not only as the learning objective but also as the way of the learning process itself. OECD [6] and Mellone, Verschaffel & Dooren [7] stated that the ability to solve the problem is very important, not only for those who study mathematics but also the ability in understanding and solve the situations in the real world.

In the problem-solving process, the students are expected to understand the problem-solving process, be skillful in selecting and identifying the relevant condition and concept, find generalization, formulate adequate procedure plan to solve the problem and organize the skill previously owned [8]. In fact, a math-learning process in school gives less chance for students to develop their ability in solving problems. The teacher does not habituate the students to practice to solve the problems in the learning process. Therefore, the percentage of the problem-solving ability is categorized as low.

In fact understanding concept in problem solving is important to be thought because it plays an important role in students' problem-solving in developing a high level of thinking ability [9], [10]. The ability to solve problems is related to students' understanding ability; it is because of the understanding toward the general problem in the most common problem encountered in students' daily life (Mustafić, Niepel & Greiff [10]; Orzechowski, Kruchowska, & Gruszka, [11].

The result of the observation in several junior high schools with 154 sample students in three schools located in

Kahu sub-district showed that average 60% of the 8th-grade students' problem-solving ability in mathematics was still in the low category. The effect of the low ability made students tend to solve the problem by copying the problem solving demonstrated by the teacher as shown in solving a number of problems. Besides that, the students had difficulties in applying a concept to solve an irregular problem or real problems related to the learned concept. Therefore, it needs a lot of effort to increase the ability of mathematics problem-solving. One of them is a learning model of Problem Posing and Solving (PPS). Problem Posing and Problem Solving learning model are enabled students to connect their knowledge with their experiences, teach them to think critically and scientifically by connecting real-world concept so that it produces better conceptual understandings and eventually motivates them to study.

This study scientifically applied the problem posing and solving (PPS) learning model in mathematics subjects, especially in Pythagoras, which aims at encouraging students' high-level thinking ability in improving students' mathematical problem-solving ability in junior high schools.

II. Research Method

The method of this study is a quantitative research design with experimental research types a quasi with the design of the study "Non-equivalent Experimental Group." In this research, before the experiment of intervention was conducted, a pre-test was given to find out the initial condition of each class. The Treatment was conducted by using the learning model of PPS (Problem Posing & Solving). The Non-equivalent Experimental Group design used is as follows:

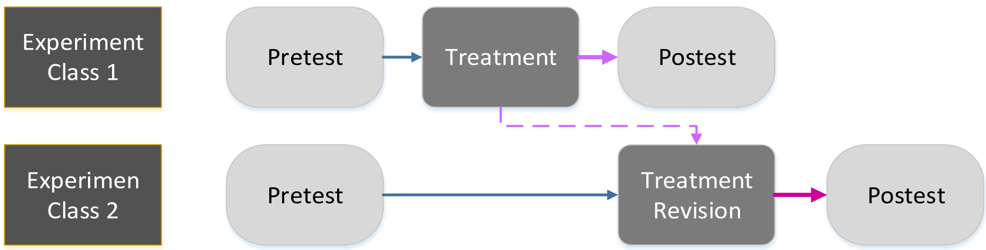

Fig. 1. Experimental Design

The sampling method in this study was a non-random sampling technique with a purposive sampling type in which the sample is determined directly through the consideration that the two samples have homogeneous characteristics and can represent the population. In this study, no randomization of the subject (students) was conducted, but randomization of the class was done to see the relationship between the research variables. The subject of this study was the 8th-grade students of SMP Negeri 4 Kahu with the first sample was the students of VIIIB class which consisted of 19 students and the students of VIIIC class which consisted of 18 students. The data retrieval was conducted by using a description test as the result of the learning and observation. The test type given was a subjective test (in the form of description). The reference in giving the problem-solving scores can be seen in table 1.

TABLE I. THE REFERENCE OF GIVING SCORE IN THE PROBLEM-SOLVING ABILITY

An aspect of Problem Solving	**An aspect of Problem Posing**	**Detail of assessment aspect**	**The rubric of Problem Solving Ability Assessment**	**Score**
Problem-solving	Formulating problem	Identifying known, questioned data, elements and complete them when needed and formulate/ formulate mathematical models of problems in the form of images and or mathematical expressions of a series of information	A mistake in proposing /interpreting problem/no answer at all	0
			A mistake in proposing /interpreting some problem or ignoring problems	1
			Correct in proposing /interpreting problems or ignoring but not complete	2
			Proposing and understanding the problem completely	3
Solution Planning	Formulating problem	Identifying several strategies that can be used to complete the mathematical model in question	Using irrelevant strategy /no strategy at all	0
			Using some less applicable strategy and cannot be continued or lead to the wrong answer.	1
			Using several strategy/procedure which leads to the correct answer (correct solution)	2
Implementation of solving planning	Detailing the Main Problems in Part Problems	Establishing / choose the most relevant strategy and complete a mathematical model based on the drawing and mathematical expression that has been formulated	No solution at all	0
			Detailing some of the procedures used and leading to the correct solution	1
			The answer is wrong, or some answer is wrong in solving the problem	2
			The process of problem-solving is well elaborated and correct answer	3
Recheck of the result of problem-solving	Preparing Problems Before, During and After Problem Solving	Check the correctness of the solution to the initial problem	There is no checks or no information	0
			There is checking but it's not complete	1
			The examination is carried out to see the results and process information	2

This study used a quantitative analysis, in which the analysis was conducted by calculation. From the obtained data, the statistic calculation was done through analysis, synthesis, and evaluation. The Statistic calculations used were Normality, homogeneity, gain, independent sample t, and Effect size test to find out how effective PPS learning method toward the improvement of students' problem-solving ability was. The effectiveness of the learning model implementation can be calculated by finding how significant the contribution (effect size) of the learning model implementation. The effective contribution (Effect size) explained how many percents of contribution of intervention given in increasing students' score in the mathematics problem solving of the experimental groups. The Size effect was calculated by using Cohen equation. The formula of the Cohen effect size is as [12].

$$d = \frac{\bar{X}_{Post} - \bar{X}_{Pre}}{S_{pooled}} \quad (1)$$

Whence:

D : Effect Size value
$\bar{X}_{Post}$: Average pre-test score
$\bar{X}_{Pre}$: Average post test score
S_{pooled} : Standard deviation

$$s_{pooled} = \sqrt{\frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{(n_1 - 1) + (n_2 - 1)}} \quad (2)$$

whence:

S_{pooled} : Standard deviation
n_{Post} : Number of pre-test samples
n_{Pre} : Number of post-test samples
s_{Post} : Standard of pre-test deviation
s_{Pre} : Standard of post-test deviation

Criterions proposed by Cohen about the effect size are 0 < d < 0,2 Low effect (average margin less than 0,2 standard deviation), 0,2 < d < 0,8 Medium effect (average margin less than 0,5 standard deviation), d > 0,8 High effect (average margin less than 0,8 standard deviation)

III. Result and Discussion

This research was conducted at SMPN 4 Kahu. In this study, two classes were used as samples which consisted of 19 students in class VIII B and 18 people in class VIII C. the selection of class VIII students was that the eighth-grade students had studied Pythagoras in the previous semester so that it was possible to pretest or test students' abilities about Pythagoras problems. The class preparation until the implementation was not independent of the role of teachers in mathematics subjects.

To find out the differences in students' problem-solving abilities, an initial test (pretest) and final test (post-test) were given. The pretest was done before the students were given a different treatment in the learning process while the post-test was done after the students were given a different treatment in the learning process. The learning steps are shown in Fig. 2.

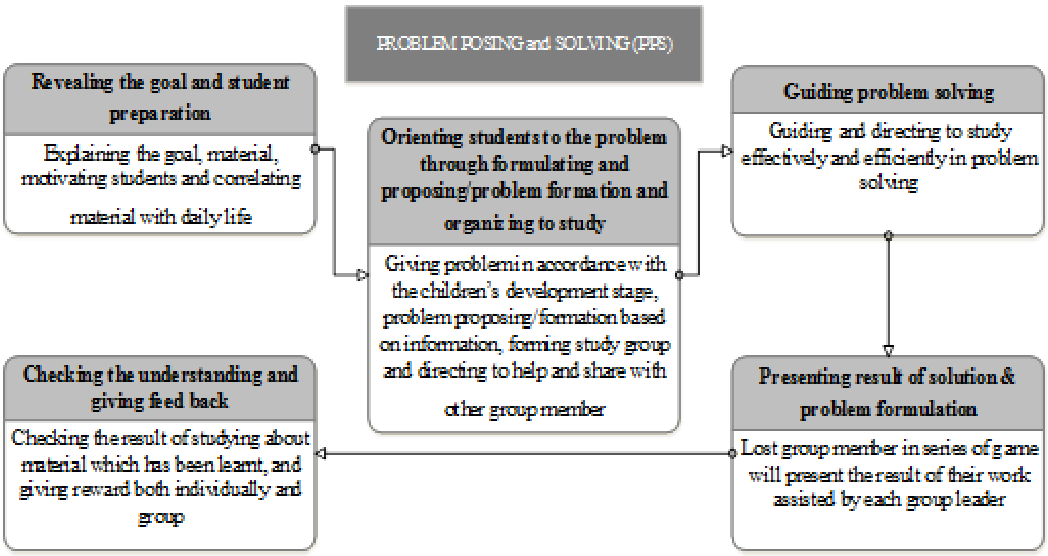

Fig. 2. Steps of PPS learning model

The steps of the learning in figure 2 are elaborated as follows:

A. *Revealing goals and preparing students.*

The teacher explains the learning objectives, the logistics needed, motivates students to be actively involved in the selected problem-solving activities. During the analysis and explanation phase, students will be encouraged to express their ideas openly and freely

B. *Orient students on problems through solving or formulating problems and organizing them for learning.*

The teacher gives examples of problems in the form of story and transforms them into a mathematical model to be solved. Teachers can begin learning activities by forming student groups where each group will choose and solve different problems.

C. Guide individual or group completion

At this stage, the teacher must encourage students to collect data and carry out experiments. After students collect enough data and provide problems about the phenomena they investigate, then they begin to offer explanations in the form of hypotheses, explanations, and solutions.

D. Presenting the results of problem-solving and formulating the problem.

The teacher helps students plan and prepare appropriate works such as reports, videos, and models, and helps them to share assignments with their friends. The next step is to show off the results.

E. Check the understanding and provide feedback as an evaluation.

During this phase, the teacher asks students to reconstruct the thoughts and activities that have been carried out during the learning process. At the end of the teacher learning process, the teacher finds out the ways to respect both individual or group learning outcomes.

After the treatment process, a post-test was conducted to see the differences in the mathematical problem-solving abilities with the same level of questions during the pre-test. This was a guideline in seeing the increasing success of PPS-based learning model in improving students' mathematical problem-solving skills. The test instrument used for each study consisted of five description questions with reference to the predetermined indicators.

From the results of statistical data analysis, it was obtained the average value of mathematical problem-solving ability in the first experimental class at the pre-test was 26.00 average while the second experimental class was 25.21 average. This value is still below the minimum completeness standard that must be achieved by students, while the average value of the problem-solving ability in the post-test in the second experiment class was 63.94 with a gain of 38.73 higher than the first experiment class with 60.61 average with a gain of 34.61. This indicates that an increase in the average of students' mathematical problem-solving abilities after the application of the PPS learning model. The data from the description of the processed data are described below.

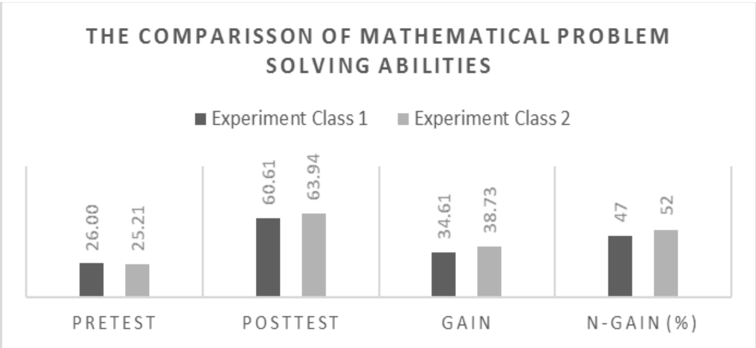

Fig. 3. The comparison of Test Result in the Problem Solving Abilities

To test whether there was a difference from the two average problem-solving abilities of each experimental class, the data was tested by using normality and homogeneity. The normality tests performed with Saphiro Wilkyang by SPSS by comparing the probability of p with an alpha (α) value, the test criterion was if the probability was $p >$ alpha (α), the test results were said to be normally distributed. The results of the calculation of the data normality test are shown in Table 2.

TABLE II. NORMALITY TEST OF EXPERIMENTAL CLASS DATA CONTROL CLASS

	Experiment Class 1		Experiment Class 2	
	Pretest	**Posttest**	**Pretest**	**Posttest**
P	0.244	0.201	0.234	0.183
α	0.004	0.410	0.100	0.116
Explanation	Abnormal	Abnormal	Abnormal	Normal

After knowing the pre-test and post-test scores of students' mathematical problem-solving abilities in the experimental class were more dominantly abnormal distributed, then the next step was to test the variance homogeneity of the data. The criteria of homogeneity test were done by comparing significant Asymp numbers. Sig with an alpha (α) value, with the requirement, if the number is significantly greater than α (0.05), then the test results are considered homogeneous.

TABLE III. DATA HOMOGENEITY TEST

	Levene Statistic	df_1	df_2	*p*	Explanation
Pretest	0.375	1	35	0.554	Homogeneous

Based on the above output, it is known that the significance value of $p > 0.05$, so it can be concluded that the variance of the pretest and posttest in the experimental class and control class is same or homogeneous. Based on the results of the prerequisite test shows that the data was not normally distributed, therefore the data were analyzed to test the hypotheses with nonparametric statistics. Nonparametric statistical tests in this study used the t-independent test. Based on the data it was obtained data as follows.

TABLE IV. HYPOTHESIS TEST OF PPS LEARNING MODEL IMPLEMENTATION IMPROVEMENT OF EXPERIMENTAL CLASS

	Experiment Class 1	Experiment Class 2
Z	-3.823	-3.622
P	< 0.001	< 0.001

Based on the "Test Statistics" output of the Wilcoxon test above, it is known that $p < 0.05$, it can be concluded that there is an increase in the average mathematical problem-solving ability of both the first Experiment and the second Experiment class after the application of the PPS learning model. To see the difference between the two classes after the application of the PPS learning model, the Mann-Whitney U test was performed. Mann-Whitney U test results obtained was p <0.05 (0.002 <0.05) thus it rejected the null hypothesis. This means that there is a difference in the average problem-solving ability in the two experimental classes. The calculation results are presented as follows.

TABLE V. HYPOTHESIS TEST OF AVERAGE DIFFERENCE OF PPS LEARNING MODEL

Hypothesis Null	Test	p	Decision
There is no difference in Increasing the average score of the gain index of problem-solving ability of students who use the PPS learning model in both the Experimental Classes.	Mann-Whitney U	0.002	Rejected the null hypothesis

The next test was to test the effect size, which was useful to test the size of the treatment effect, namely the application of the PPS learning model, the calculation result is as follows.

TABLE VI. EFFECT SIZE OF PPS LEARNING MODEL IMPLEMENTATION

Effect Size Test	Test I	Test II
d Effect Size	2.207	2.272
r Effect Size	0.733	0.744
σ pooled	15.683	17.049
S pooled	16.138	17.516

From the calculation result, it was obtained the effective contribution of the treatment that is the application of PPS learning model in improving students' mathematical problem-solving ability in the first test of is 2.207 and the effect size based on r is 0.733. The result of the first test is increased in the second test with the effect of applying of the PPS learning model as much d = 2.272 and the effect size r = 0.743. The first test and the second test are in the big effect category or means that the application of the PPS learning model is effective in improving students' mathematical problem-solving skills.

IV. CONCLUSION

The difference of hypothesis test with Mann-Whitney was $p < 0.05$ it means that there is an average difference of gain from both experiment classes with the gain from the first experiment class was 34.61 (N-gain = 47%) meanwhile in the second experiment class the gain was 38.73 (N-gain = 52%). This result was strengthen by Wilcoxon test which obtained from each experiment class $p < 0.05$ which means that there was an increase of the problem solving ability for both experimental data and effect size test of the first experiment class (2.207) and second experiment class (2.272), both experiment classes shows that both classes are categorized as high effect that the PPS learning model has high effectiveness in increasing students' problem-solving ability.

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