The effect of predict-observe-explain (POE) learning model using open-ended problem (OEP) towards students' mathematical problem solving skill

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Abstract

The research aims to determine the diversification of the students' mathematical problem solving skill differences with the Predict-Observe-Explain (POE) learning model using open-ended problem (OEP), students who are using POE learning model and students who following conventional learning. This research is quasi-experiment with post-test only control group design. The population that is observed in this research is students of Senior High School number 5 Denpasar 2018/2019 school year in eleventh grade. Sample which has been picked is 3 classes using cluster random sampling technique. There are from 3 classes have been chosen 2 classes are being experimental classes and 1 class is a control class. Students' mathematical problem solving skill measures using mathematic problem solving skill test. Data that is gained analyzed using one way ANOVA to find out the first hypothesis and continued with scheffe test. Hypothesis test result showed that: firstly, there are differences of mathematical problem solving skills between students who used POE learning model using open-ended problem and students who followed conventional learning method ($F_{count} = 19,24$ and $F_{table} = 3,08$; $F_{count} > F_{table}$); secondly, students' mathematical problem solving skill by the students who use POE learning model is better than students who following conventional learning ($F_{scheffe} = 10,43$ and $F' = 6,16$; $F_{scheffe} > F'$); third, students' mathematic problem solving skill with POE learning model using open-ended problem is better than the students who followed conventional method conventional ($F_{scheffe} = 9,09$ and $F' = 6,16$; $F_{scheffe} > F'$); fourth, students' mathematic problem solving skill using POE learning model using open-ended problem is better than the students who only got conventional learning ($F_{scheffe} = 38,46$ and $F' = 6,16$; $F_{scheffe} > F'$). It can be concluded that the POE learning model using open-ended problems give an influence on students' mathematical problem solving skill.

Keywords: *POE learning model; open-ended problem; conventional learning; mathematics problem solving skill.*

Introduction

Problem solving skill is one of the important skills of the student which has to be improved. In teaching and learning process, the successfulness of students in order to problem solving which has been given from the teachers influences by students' problem solving skill (Son and Lee, 2016). It is based on the 5 process standard in mathematic learning NCTM (2000) that is problem solving, reasoning and prove, communication,

connection and representation. Based on Kostousov and Kudryavtsev (2017), education should equip students with not only in knowledge aspects but also to prepare them in solving the problem in the real world. Besides that, based on Tösten et al. (2017) problem solving skill is one of the important skills that is hoped can be gained from the educational aspect. So that formal education in the school is hoped to maximally improve students' ability in solving the problem in mathematics. But problem solving is still being considered as the hardest part in mathematic whether for the students who study at it and the teachers who teach about that.

Remember about mathematical problem solving skill, teachers have to create an innovative learning system which makes students as the center based on the teaching materials in which could improve students' mathematics problem solving. One of them is the way of choosing a learning model that suitable in which students' centered so that improving students' problem solving skill. Student-centered learning means that the students give a chance to has their autonomous through education, so the students have to be more active in order to find out and solve the problem that is faced by the students (Jacobs dan Toh-Heng, 2013).

The learning model is a learning concept framework that draws the systematic procedure and organizing learning experiences to gain a specific purpose and has a function as a guideline to plan out and learning process (Sudiarta, 2010). There are some innovative learning models that could improve students' mathematics problem solving skill, one of them is the POE learning model.

POE learning model is a learning model that is based on the constructivist theory because the students will build up their knowledge based on the observation that is done directly in the teaching and learning process (Joyce, 2006). Learning model POE firstly developed and introduced by White and Gunstone in 1995 in their book *"Probing Understanding"* which stated that the POE learning model as efficient learning to pop idea or opinion informing discussion.

POE learning model consists of three main stages those are predicting, observing, and explaining (explaining the relationship between predict and observe). The outline of the learning model, (Liew, 1998) is stating that the stages of learning using the POE learning model are the students given a problem and then based on their understanding and knowledge the students aim to firstly predict the solution of that problem with reasons. After attending the initial prediction and planning strategy that will be used to solve the problem. When the

initial prediction and observation result has been matched, so the students explain the result of its observation that has been done. The stages which existed in the POE learning model give students more space to choose their knowledge in order to solve the problem to become more effective and meaningful. This is supported by the research has been investigated by Ariyani (2014) concluded that students who have been done POE learning model has an ability of critical thinking that is better than the students who only following conventional learning.

In order to maximize the students' mathematic problem solving skill so it is needed to have a problem that could open up students' insight largely and students' critical thinking. Based on that thing, someone who has critical thinking can provide a logical answer based on their ability so this critical thinking ability is needed for solving a mathematics problem (Sari, 2014). High level of intellectual skill can be improved by solving the problem, so it is needed a problem which can dig creativity, critical thinking and high-level thinking in which will forming the growth of students' problem solving skill (Cardellini, 2014).

The problem that is suitable to accommodate that thing is an open-ended problem. An open-ended problem is a problem or mathematic test that is planned to have some ways or correct solutions and has lots of ways to solve and find out the solution (Sudiarta, 2008). Mathematic learning by using open-ended problems will press the students to explain the mathematic logical thinking that they have with the reason that can be a valuable material for teachers in the teaching and learning process. The use of open-ended problems in the students learning process will make the students trained in order to solve the mathematics problem. There is not only a general problem but also an open-ended problem in which this problem will give the students' chance to investigate a lot of strategies to solve the problem that is faced by the students (Suryawan, 2014). Besides, using open-ended problem can growing students' independence in the learning process and giving a chance to the teachers to do guidance whether it belongs to individual or group, so it is hoped can be improving students' motivation in studying that will create an improvement on their skill in solving the problem.

This is supported by research related to the open-ended mathematical problem that has been investigated by Kumarayasa (2016) with the title "The Effect of Generative Assisted Open-Ended Mathematical Problem Learning Model Toward Mathematics Problem Solving". This research shows a result that generative assisted open-ended mathematical problem learning models effective to improve students' problem solving skill. This research

also concluded that using open-ended problems in the learning process causes students to be challenged and motivated to solve the problem given.

In addition, there is no adequate research on the effect of the POE learning model using open-ended-problem towards students' mathematical problem solving skill. Based on that analysis, it can be expected that there is an influenced POE learning model using open-ended problems towards student's mathematical problem solving.

Materials and Methods

This research is quasi-experimental. Quasi-experimental can be used to see the effect that is caused by different treatments that are given to each group, where the researcher can't control all variables and experiment conditions tightly (Sugiyono, 2015). A research design that is used as a post-test only control group that is shown in Table 1.

Table 1. Research Design

Group	Treatment	*Post Test*
Experiment 1	X_1	*O*
Experiment 2	X_2	*O*
Control	-	*O*

X_1 : POE learning model using open-ended problem treatment

X_2 : POE learning model treatment

O : Post-test

The population of the study is the students in grade XI in Senior High School number 5 Denpasar with 2018/2019 school years consisting of 12 class. The technic of picking the sample in this study is using *cluster random sampling* where the sample is chosen not based on individuality but based on the group. Before withdrawing the sample, the researcher is doing sample equalization. Equalization test needs normal data distribution and homogeny variety so before an equalization test, it has to be held normality test and homogeneity test. The test is continued with ANOVA one-way test. Based on its counted it gains F_{count} about 2,837. There is also a value of F_{table} around 3,085. So that those three groups almost equal.

After three sample groups are gained equalized the lottery is held to determine the groups for being the 1st experimental group, 2nd experimental group, and control group. The

result is XI Science 7 as the 1st experimental group that will be given treatment with the POE learning model using open-ended problem, XI Science 9 class as the 2nd experimental group in which will be given POE learning model and XI Science 8 class as the control group with conventional learning.

After the sample group has given treatment so that at the end of the research the students will be given a test of mathematical problem solving skill in the form of an essay. After that, it will be continued with assumption test those the normality test data distribution with Liliefors, homogeneity test varians using Levene test. Then, the hypothesis test firstly with using one-way ANOVA and continued with Scheffe test.

This research is deliberating with the independent variable and dependent variable. The independent variable in this research is the POE learning model using open-ended problem, POE learning model and conventional learning that is used in mathematics. Thus dependent variable in this research is the students' mathematic problem solving skill. The data of this research is students' scores of tests after they got a problem solving skill essay test.

Results and Discussion

Data on student's mathematical problem solving score tests achieved from the post-test that is given to the three groups of the sample that can be seen from this table.

Table 3.Summary of analysis on students' mathematical problem solving score

Variable	Sample		
	Experimental Class I	**Experimental Class II**	**Control Class**
N	35	36	35
$(\bar{X})$	200,66	173,97	145,40
(SD)	33,45	43,45	33,63

Note:

N : the number of students

$\bar{X}$: average score of students' mathematical problem solving skill

SD : standard deviation

From Table 3 can be found that the average of students' mathematical problem solving score are different from class that will be given treatment with POE learning model using open-ended problem, class in which will be given POE learning model and class with

conventional learning in which the class that will be given treatment with POE learning model using open-ended problem get the highest score.

Summary of data normality test for experimental group and control groups can be seen on this table.

Table 4. Normality test summary

Sample Class	L_{count}	L_{table}	Result
Experimental 1	0,088	0,224	Normal
Experimental 2	0,079	0,221	Normal
Control	0,145	0,224	Normal

Normality distributional data test result can be seen on Table 4 above, for the score of students' mathematical problem solving skill class that will be given treatment with POE learning model using open-ended problem has L_{count} around 0,088 meanwhile in class in which will be given POE learning model around 0,079 and class with conventional learning around 0,145 in the significance level 5%. From that counted found data from those three sample classes has L_{count} smaller than L_{table} in which means that students' mathematical problem solving score data from three sample classes normally distributed. It continued with the result that is gained that $W = 0,718$ and $F_{table} = 3,085$. If it is compared $W < F_{table}$. So that H_0 is accepted and can be concluded that students' mathematical problem solving test score is homogenous.

Hypothesis test firstly showed that F_{count} around 19.24 with $F_{table} = F_{0,05(103,2)} = 3,085$ so that $F_{count} > F_{table}$. It can be concluded the difference of the skill in solving the problem of mathematic between students that learn with the POE learning model using open-ended problems, students who use the POE learning model and conventional learning. Hypothesis test can be tested again with a follow-up test.

The second hypothesis test is using ANOVA test in which using *Scheffe* test as follows

$$F_{hit} = \frac{(\bar{Y}_B - \bar{Y}_K)^2}{S_D^2(\frac{1}{n_B} + \frac{1}{n_K})} = \frac{(173,97 - 145,4)^2}{1389,18(\frac{1}{36} + \frac{1}{35})} = 10,429$$

Thus, $F_{count} = 10,429$ and $F' = (k-1)F_{table} = 6,16$, it is gained that $F_{count} > F'$. So H_0 is rejected, in this means that the difference that existed between μ_2 and μ_3 can be stated as significantly different. It means that students' mathematical problem solving skill

differences that are learned with POE learning model is better than students' mathematical problem solving skill of students who got conventional learning.

Third hypothesis test result using the following ANOVA test that is using *Scheffe* test as follows:

$$F_{hit} = \frac{(\bar{Y}_B - \bar{Y}_K)^2}{S_D^2\left(\frac{1}{n_B} + \frac{1}{n_K}\right)} = \frac{(200,66 - 173,97)^2}{1389,18\left(\frac{1}{35} + \frac{1}{36}\right)} = 9,097$$

In which $F_{count} = 9,097$ and $F' = (k-1)F_{table} = 6,16$, it is gained that $F_{count} > F'$. In which H_0 is rejected, it is shown that there is a difference that is shown between μ_1 and μ_2 could be stated as significantly different. Its means that the students' mathematic problem solving skill of the students who are learning with POE learning model using open-ended problem is better than the skill of students who learn only using POE learning model.

Fourth hypothesis test result using the following ANOVA test that is using *Scheffe* test as follows:

$$F_{hit} = \frac{(\bar{Y}_B - \bar{Y}_K)^2}{S_D^2\left(\frac{1}{n_B} + \frac{1}{n_K}\right)} = \frac{(200,66 - 145,4)^2}{1389,18\left(\frac{1}{35} + \frac{1}{35}\right)} = 38,46$$

The result of $F_{count} = 38,46$ and value $F' = (k-1)F_{table} = 6,16$is gained $F_{count} > F'$. This H_0 is rejected, this means that the difference that appears between μ_1 with μ_3 which can be stated as significantly different. It means that the difference between students, mathematical problem solving skill with the POE learning model using an open-ended problem that is better than the students who only got conventional learning in their class.

Analysis result of students' mathematic problem solving skill on three classes sample that is the class that treated with POE learning model using open-ended problem, using POE learning model and conventional learning showed that the average of students' mathematical problem solving skill in the class will be given treatment with POE learning model using open-ended problem is higher than the average of the students in class which will be given POE learning model and class with conventional learning. That result is also shown that the average of students' mathematical problem solving skill in the class will be given POE learning model is higher than the class with conventional learning. Thus for the class with POE learning model using open-ended problem, the average of students' mathematical

problem solving skill score is 200,66, then the average of students' mathematical problem solving skill score on the class using POE learning model is 173,97, and the average of students' mathematical problem solving skill in class with conventional learning is 145,40. Continued by the hypothesis testing result score of students' mathematic problem solving skill through 3 classes that is class will be given treatment of using POE learning method assisted by open-ended mathematics problem, class will be given POE learning model, and class with conventional model where because of those sample normality distributed and homogeny variant, thus is continued with hypothesis test that is using one way ANOVA test to find out whether the difference of students' mathematic problem solving between those classes. From those test has been found that F_{count} is 19,24 and $F_{table} = 3,085$. Value $F_{count} > F_{table}$, so that H_0 is rejected. It is found the differences of students' mathematical problem solving between class will be given treatment with the POE learning model using open-ended problem, class in which will be given POE learning model and class with conventional learning.

After doing one way ANOVA test that is followed by doing *Scheffe* test and the result is students' mathematical problem solving skill using the POE learning model has significantly different from the students who only learn using conventional learning. So that being continued that the students who learn with the POE learning model using open-ended problems have been gaining better results rather than only using the POE learning model. The final conclusion is students' mathematical problem solving skill of the students who have trained with POE learning model using open-ended problem is better than the students' skill that is trained using conventional learning.

The students who have following the POE learning model can understand and plan the strategy to solve the problem in a better way rather than the student that is trained using conventional learning. The students who are trained using POE learning model makes the students more socialize and understand the problem in order to create the strategy for solving until could improving students' argumentation skill. Making students used to do that makes the students be more open-minded in giving argument towards the problem that has been given. POE learning model is also training the students to organized working in order to solve the problem. Besides, the students who learn using the POE learning model have to be developing their prior knowledge so that they can predicting and also observing in which in the end they could explain the suitability or unsuitability between their prediction and observation.

The class will be given treatment with the POE learning model using open-ended problems is using with open-ended problems. This learning process is similar using the POE learning model but the difference is the open-ended type of mathematic problem used. The use of open-ended problems can grow and open students' knowledge to be larger, it is because the students are faced with the test that is incompletely designed or has missing information. From that thing, the students will automatically search for the possibilities that can be used in solving the problem and the students also can socialize more or collaborate with their groups. The use of open-ended problems in the learning process will make the student be trained in order to solve the mathematics problems. Besides, the use of open-ended problems gives a chance for students to do an investigation towards some strategies that might be used to solve the problem. Otherwise, a close-ended problem that is formed so that only has one solution will make the student's chance of improving their creativity is limited. In the process of studying, the students divided into some heterogeneous groups that given open-ended mathematics problems. So, each of the groups should give their predictions about the problem that has been given. The purpose of that is too grown-up the students' prior knowledge. Then the students continued with doing observation through the given problems. From doing the observation, the students will understand the problem that is given and find out the possible strategy that is used to solve the problem. After giving the prediction and doing observation, the students have to explain about the suitability and unsuitability of their prediction and observation result.

The second experimental class held the POE learning model in which the students are a form of heterogeneous groups. The class is opened by giving every group problem and then every group giving their prediction towards the problem that is given. After giving a prediction, every group was doing observation and planning the strategy of solving the problem. After that, the students explained their suitability and unsuitability between their prediction and the observation result. The conventional learning in the school is being done using the cooperative model. In the form of groups, there will be a discussion using students' worksheet that has been given to the students. It affects the lack of participation of students with the teaching and learning process in the class that is dominating by the teacher. It happens because when the discussion section between the group there still a lot of the students that seems like giving the work only to the several members of the group which makes the teacher has to be more active to give the students' explanation by giving an example of the test answer etc. On conventional learning, the students are not being a

facilitator so when students don't understand the material they will automatically ask the teacher whether asking their other friends. So, the students seem not constructing their own concept and being depended on the teacher in the class.

Generally, the POE learning model using open-ended problems can be successfully operated. So, based on the hypothesis test result and descriptive concept of comparison between those learning models above can be seen that the POE learning model using open-ended problem gives a positive influence towards students' mathematical problem solving skills. Thus is proven by the post-test result that showed the students' mathematical problem solving skill in the class with the POE learning model using open-ended problems has significantly different rather than the students who only trained using the POE learning model and conventional learning.

Conclusion

Based on the explanation of result study and discussion there are some points that can be concluded such as: (1) There is a difference of students' mathematical problem solving skill between students who has been trained with POE learning model using open-ended problem, students who have trained using POE learning model and using conventional learning. (2) Students' mathematics problem solving skill that is trained using POE learning model is better than conventional learning. (3) Students' mathematical problem solving skill that is trained with POE learning model using open-ended problem is better than students' mathematical problem solving skill that is trained using POE learning model. (4) Students' mathematical problem solving skill that is trained with POE learning model using open-ended problem is better than students who are trained using conventional learning. Based on those results above can be concluded that the POE learning model using open-ended problem gives a positive influence on students' mathematical problem solving skill.

There are some suggestions that can be given based on the study results that have been conducted: (1) The other researcher is suggested to train out this method in the other dependent variable, for example studying mathematics achievement. (2) It is for the educators, especially mathematics teachers hopefully applying this POE learning model using the open-ended problem as one of the alternatives in the teaching and learning process considering a good effect in this method towards students' mathematical problem solving skills. (3) This research is been done to the limited population and teaching materials. The

other researchers are suggested to do the research using this method in a larger population and deeper teaching materials to see the influence of this learning model in mathematics in a deeper way.

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