How to Teaching Effectively using Problem-Based Learning in Probability

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Abstract. National Council of Teachers of Mathematics (NCTM) argued that problem-solving should be a focus on mathematics learning. It requires a learning model to support problem-solving ability. The study aimed to determine the effectiveness and influence of the problem-based learning model in student learning outcomes of probability. This study was a quasi-experimental research whose population of all 8th graders in SMP N 3 Bantul. The data collecting techniques were learning outcomes test of probability and instructional learning sheets. The effectiveness and influence of problem-based learning using Kolmogorov Smirnov analysis test, Lavene test, and t-test using significance 5%. The results show that three indicators of competence are in very high category. While competency indicators solving problems related to empirical probability and determine the probability complement into the high category.

Keywords: Problem based learning model, learning outcomes

1. Introduction

International Trends of Mathematical and Science Studies (TIMSS) show that on 2015 the ability of Indonesia students in mathematics is 45th with 397 points [11]. The weakness of Indonesian students by TIMSS are reasoning aspects (to compared with other aspects), questioning, computing, and measuring. The students not being able to apply the basic knowledge, not being able to understand and apply knowledge in complex problems, making conclusions, and compiling the reasoning causing the ability of students to remain at a low cognitive level [17]. TIMSS is one of the mathematical assessments in the world. Ujian Nasional (UN) is one of the final assessments of learning outcomes in Indonesia by article 2 paragraph 1 of Permendikbud No.4 of 2018[14]. One subject that becomes an indicator of the UN is mathematics. Mathematics abilities in Indonesia can be captured by some material, such as numbers, algebra, geometry, and probability. Based on the results of the UN for the last three years at SMP N 3 Bantul, it shows that four materials the probability have the lowest average value. It seen from by the data of the average national examinations which is resulted on table 1.
Table 1 The Absorptive capacity of UN N 3 Bantul Middle School

| Aspect   | Year | Average value | School | National | Province |
|----------|------|---------------|--------|----------|----------|
|          | 2014 | 71.29         | 60.44  | 64.12    |          |
| Probability | 2015 | 79.55         | 60.78  | 63.87    |          |
|          | 2016 | 72.84         | 46.73  | 55.99    |          |

Source: [8] [9] [10]

Based on table 1 the average UN score in the aspect of probability from year to year has decreased. The ability of each student to receive learning is not the same. According to [20] the characteristics of students coming from different environments cause differences in students in receiving learning. Also, this caused by the use of the model or method used by the teacher in conveying the learning material still does not facilitate students in strengthening the ability to integrate information, draw conclusions and generalise the knowledge they have to other knowledge [15].

According to [7] problem-solving ability is a very important ability in mathematics learning which involves the process of analysing, interpreting, reasoning, predicting, evaluating and reflecting. In line with that conveyed by Karatas, according to [16] problem-solving abilities support students to think critically, logically and creatively. A learning model is needed to support problem-solving abilities for students. Problem Based Learning (PBL) is an invention-based learning that can be used in mathematics learning and significantly helps students in achieving learning goals [6]. According to [3] PBL as an alternative learning model that can help students in finding new ideas and the ideas obtained affect creativity in learning. Students who use PBL have a greater chance to learn mathematical processes related to communication, representation, modelling, and reasoning [1]. PBL learning objectives according to [4] for students: a) build broad and flexible knowledge, b) become effective collaborators, c) develop effective problem-solving skills, d) be motivated to learn, and e) develop independent learning skills. The steps used in the PBL model are 1) giving the problem orientation to students, 2) dividing students into groups, 3) helping students in the group investigation, 4) developing and presenting experimental results, 5) analysing and evaluating the process experiment [3].

Cooperative learning is a learning model that involves students working together in groups to achieve common goals [2]. According to [19] cooperative learning is structured with positive/interdependent indicators between groups. The principles of the cooperative learning model according to [2] are 1) each member complement each other between groups, 2) each member is accountable and evaluates the results of individual and group work, 3) each member collaborates to achieve common goals, 4) in cooperative learning, students obtain better social skills, 5) At the end of group work, students collect and discuss projects and achieving goals.

2. Method

This experimental research design used Quasi-Experimental Design in the form of Nonequivalent Pretest-Posttest Control Group Design. The form of this research design shown in Table 2.
Table 2 Nonequivalent Pretest-Posttest Control Group Design

|     | \(O_1\) | \(X_1\) | \(O_2\) |
|-----|---------|---------|---------|
|     | \(O_3\) | \(X_2\) | \(O_4\) |

Source: [18]

Information:

\(X_1\): Treatment of experimental group problem-based learning models on probability

\(X_2\): Treatment of control group cooperative learning models on probability

\(O_1\): Pretest to measure the ability of an experimental group on probability

\(O_2\): Posttest to measure the ability of an experimental group on probability

\(O_3\): Pretest to measure the ability of control group on probability

\(O_4\): Posttest to measure the ability of control group on probability

The population in this study were all students of class 8th SMP N 3 Bantul. The sampling method was done by simple random sampling. In this way, class 8th-G was chosen as the experimental with PBL class and class 8th-H as the control class with cooperative learning as model. Data collection techniques are carried out by tests and observations. While the instrument used is a matter of pretest and posttest ability of students on probability and observation sheets. Data from the pretest will be used to determine the students' initial ability before being given treatment, both in the experimental class and in the control class. Whereas the posttest result data will be used to determine the effectiveness of the learning used, both in the experimental class and in the control class.

The technique of analysing the results of the post-test data included the normality test using the Kolmogorov-Smirnov test and homogeneity test using the Levene test. While the hypothesis test is t-test with SPSS 21.

3. Results and Discussions

3.1. Result
The pretest and posttest questions used were a matter of description consisting of 5 questions. Each item through filtering validity and reliability testing. To find out the ability of learners on the probability, then the average value of the competency achievement indicator calculated for each item is presented in table 3 as follows.
mention the sample room

Determine the probability of an event

Determine the frequency of hope

Determine an probability presented in graphical form

Determine the frequency of hope by looking for complementary probability

The result it was found that the highest indicator achievement was found in the competency indicators mentioning the sample room, which was 84 in the experimental class and 91 in the control class. While the achievement of the lowest indicator is to determine the probability presented in graphical form with the achievement of indicators of 73 in the experimental class and 63 in the control class, that is, students have been able to understand and analyse the intent and purpose of the problem but have not been able to change the questions presented in the form of images into the form of stories. The achievement of indicators determines the frequency of expectations by looking for probability for complement is also still low, which is equal to 75 in the experimental class and 67 in the control class. That is, students have not been able to analyse and solve complex problems. The result is consistent with the opinion of [17] that students are accustomed to being presented with routine and simple computational questions.

In more detail, the results of the posttest in the experimental class and control class are presented in table 4 as follows.

| Calculation                    | Experiment Class | Control Class |
|--------------------------------|------------------|---------------|
| Average                        | 78,60            | 73,80         |
| Variance                       | 38,583           | 44,333        |
| Deviation                      | 6,212            | 6,658         |
| Maximum                        | 90,00            | 85,00         |
| Minimum                        | 70,00            | 65,00         |

Based on table 4, it can be seen that the experimental class has a higher average than the control class. The average experimental class is 78,60 with a standard deviation of 6,212 or the average control class is 73.80 with a standard deviation of 6,658. The standard deviation in the class is greater than the standard deviation in the experimental class.

Hence, the normality test and homogeneity test were carried out. The normality test functions to find out whether the data is normal. Normality tests need to ensure that the statistical tests used in hypothesis testing can be done. The normality test was used the Kolmogorov Smirnov test using SPSS.
Table 5 Normality Test Results

|          | Kolmogorov Smirnov |
|----------|--------------------|
|          | Statistic | dF | Sig.  |
| Value    | Experiment | ,159 | 25  | ,104  |
|          | Class      | ,172 | 25  | ,056  |

Based on table 5, the results of the normality test can be concluded that the posttest value data in the experimental class and control class are normal. It evidenced the significance value of the Kolmogorov Smirnov test results in the experimental class of 0.104 and the control class of 0.056 greater than the α which is determined, namely α = 0.05.

Homogeneity test is done to find out whether the two samples used have the same variant value or not. The homogeneity test was carried out by levene test using SPSS 21. The homogeneity test results are presented in table 4 as follows.

Table 6 Homogeneity Test Results

| Test of Homogeneity of Variances |
|----------------------------------|
| Levene Statistic | df1 | df2 | Sig. |
| ,076              | 1   | 48  | ,784 |

The homogeneity test resulted by Table 6, it can be concluded that the significance value of the Levene test is 0.784. Because the significance value is greater than the specified α with α =0.05, then the two classes are declared homogeneous. Thus the results of the prerequisite test analysis obtained that the students’ ability data in the experimental class and control class were normally distributed and homogeneous. So that it can be continued by testing the hypothesis by using the t-test using SPSS 21 assistance.

The first hypothesis test aims to find out whether the problem-based learning model is effective in the probability. The results of testing the hypothesis are presented in table 7 below.

Table 7 Results of the First Hypothesis T-Test

| One-Sample Test |
|-----------------|
| Test Value = 75 |
| t   | dF | Sig. (2-tailed) | Mean Difference |
| Experiment      | 2,898 | 25  | ,008  | 3,600  |

Based on the calculation in table 7, the t count value is 2.898. While the t table for n is 25 students is 2.063. So the value of t counts ≥ t table, it means that the problem-based learning model is effective on probability.

The second hypothesis test aims to find out whether the cooperative learning model is effective on probability. Hypothesis testing results are presented in table 8 as follows.
Table 8 Results of the Second Hypothesis T-Test

|          | t    | dF | Sig. (2-tailed) | Mean Difference |
|----------|------|----|----------------|-----------------|
| Control  | -.901| 25 | .376           | -1.200          |

Based on the calculation, the t count value is -.901 whereas t table for n number of 25 students is 2.063. So the value of t count < t table. It means that the cooperative learning model is not effective on probability.

The third hypothesis test can only be done if the first hypothesis is tested and the second hypothesis is declared effective. Because testing the second hypothesis is declared ineffective, testing the third hypothesis is not necessary. So it can be concluded that learning with problem-based learning models is more effective than cooperative learning models on probability.

3.1.1. Discussions

As a result of observations made by observers, the learning process with problem-based learning models is appropriate. This is evidenced by the average of the 100% learning achievement at the first meeting and 100% at the second meeting. The problem-based learning model is effective in the material of probability, because the learning process with problem-based learning models uses real problems in everyday life as material for learning.

Another factor that influences the effectiveness of PBL models in probability is the achievement of competencies in learning activities. This is consistent with the opinion of [6] that students learn from an invention to achieve learning goals. The response of students based on observation, which follows learning with a problem-based learning model where students are more interested and enthusiastic in learning. It can be seen from the enthusiasm of students when conducting an experiment. This is in accordance with the results of the observation data on the implementation of learning, namely students active in the learning process. During the implementation of learning by using PBL models students are asked to observe a real problem, gather information in groups, conduct experiments, show experimental results, and analyze and draw conclusions from the problems presented [3]. In learning students are also given LKS to find a general form of opportunity presented through real problems.

PBL models are effective on opportunity material, this is in line with research conducted by researchers. As in the research conducted by [5] the problem-based learning model is effective towards mathematical problem-solving abilities compared to direct learning models, this is because the problem-based learning model focuses on problems that are appropriate to the problem-solving ability with experience in working on the problem both students individuals and groups in each stage there are activities to activate students. Research [13] regarding the application of problem-based learning models can improve student learning outcomes, this is due to the existence of stages in the
problem-based model, especially the problem analysis stage and literature study helps facilitate students in understanding the science concept, so that learning becomes more meaningful. As for the research conducted by [12] on the implementation of effective ICT-assisted problem-based learning models used in mathematics learning, because of the problem-based learning model students learn from a real problem associated with mathematical concepts through ICT media, besides PBL plays an important role to improve thinking skills with ICT support.

Learning with cooperative learning models is applied in the control class. Indicators of achievement of material competency probability at mentioning a sample room of 91% with a very good category, indicators determine the probability of an event by 73% with a high category, indicators determine the frequency of expectations by 75% with high, indicators determine probability presented in graphical form by 63% with high categories, and indicators determine the frequency of expectations by looking for complementary probability by 67% in the high category.

Cooperative learning models are said to be ineffective on probability, learning with cooperative learning models provides probability for students to discuss and group to achieve learning objectives so that students are actively involved in the learning process [2]. But apparently, this has not led to effective learning on probability. When viewed from the achievement of learning in the control class, the first meeting reached 93.3% and the second meeting reached 97.1%, which means that learning has been done well.

When viewed from the posttest value, the experimental class obtained an average value of 78.60 with a standard deviation of 6.212. While the control class obtained an average value of 73.80 with a standard deviation of 6.568. Apparently, the standard deviation in the control class is greater than the standard deviation in the experimental class. That is, students in many control classes get scores below average, although many also get good grades.

This situation causes students in the control class to get scores below the average assisted by the value of students above the average. So that even though the average value is higher than the specified completeness criteria, learning with the cooperative learning model that is applied in the classroom is not effective in the probability.

When all learning processes are carried out properly, students are believed to be able to master what they learn. This condition allows the student's posttest results to increase. That is, the right learning model can improve learning outcomes and be effective.

In accordance with the results of the study showed that the application of problem-based learning models is more effective than cooperative learning models on probability. This is consistent with the opinion [6] that constructivism is the root of PBL. In addition, both models use groups in the learning process but problem-based learning models are more effective in learning probability material.

4. Conclusion

Learning mathematics using problem-based learning models is more effective than cooperative learning models for class VIII SMP N 3 Bantul on probability. This is because students from the beginning of learning presented a problem and actively resolved the problem. Through the application of the PBL model that uses contextual problems by applying the principle of constructivism carried
out consistently can facilitate students in the ability to solve problems, understand problems, and generalize conclusions that require complex capabilities.

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