The effect of Process Oriented Guided Inquiry Learning (POGIL) on mathematical problem solving abilities

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Abstract. This research aimed to identify the effect of POGIL model on the students' mathematical problem-solving ability. The variables involved in this research were mathematical problem-solving abilities as an independent variable, and the POGIL model as a dependent variable. Based on the observations of researchers through interviews with mathematics subject teachers and students at Junior High School 2 Kalibagor, showed that the mathematical learning process that took place was still dominated by learning that did not involve the active role of students. The learning used is still teacher-centered and limited to information transfer, especially in the form of theoretical and mathematical equations. The population of this study was the students at seventh grade in Junior High School 2 Kalibagor, even semester in the school year 2017/2018 consist of 8 classes and amounted to 219 students. Sampling was done randomly, selected as an experimental class is 66.91 with 30 students and 55.91 as control class with 30 students. This test was validated by two mathematicians, then it was tested to a group of seventh-grade students to fulfill the validity and reliability criteria. The data were analyzed by using t-test after conducting a series of normality and homogeneity tests. It was concluded that t-test for equality of means was used for hypothesis testing that shows a significant value = 0.000 less than alpha 0.05. So that H0 is rejected, it means that students' mathematical problem-solving ability taught by using POGIL model is better than students' mathematical problem-solving ability taught by conventional learning. In other words, POGIL model influences or effects on students' mathematical problem-solving abilities.

1. Introduction
The vision of Indonesian mathematics education states that mathematics education is devoted to understanding mathematical concepts and ideas which are then applied in routine and non-routine problem solving through reasoning, communication, and connection development inside mathematics and outside mathematics itself [1]. Students are expected to be able to use mathematics and mathematical thinking, both in daily life learn and also learning science subjects [2]. The results of the data analysis of PISA 2013 stated that mathematical and scientific competencies significantly contribute to problem-solving throughout the country [3]. The main purpose of teaching mathematics is to enable students to solve problems in daily life [4]. The mathematical problem-solving ability itself is not only a goal in mathematics learning but also something that is very meaningful in daily life [5]. In the world of work; being a problem-solver can provide benefits [6]. Therefore learning should be developed to educate students to be able to realize and solve the problems that they face [7].
Process Oriented Guided Inquiry Learning (POGIL) is a method combining guided inquiry and cooperative learning in mathematics education. Students actively participate in the process of learning in POGIL [8]. Such key process skills as information processing, critical and analytical thinking, problem-solving, communication, teamwork, management, and assessment play important roles in teaching through POGIL. Increasing especially the skills which are necessary for achievement at school and in life is related with lifelong learning and with process education which is a philosophy of education focusing on increasing the continuation of lifelong learning because both students' cognitive skills and their process skills influencing the process of learning are very important in POGIL [9].

Problem-solving skills are needed in dealing with problems of daily life, especially in mathematics learning. Solving problems can be seen as a process of finding combinations of rules that have been learned that are used to solve problems. Mathematical problem solving is a process in which someone is faced with concepts, skills, and mathematical processes to solve mathematical problems [10].

This requires the design and application of a series of steps to achieve goals in accordance with the given situation. The opinion that mathematical problem solving provides benefits to students in the form of: (1) Can show how material related to real life, (2) To introduce and enhance discussion on a topic, (3) To motivate students to learn and master a material [11].

To measure students' problem-solving abilities, a problem of problem-solving is used. The teacher should not give too far a solution, let students guess before the teacher teaches it [12]. There are four steps in solving problems, (1) understanding problem (understanding the problem); (2) making plans (preparing plans); (3) implementing plans (implement plans); (4) checking back (look back) [13]. One of the causes of this problem is possible because the way to manage learning that still does not provide many opportunities for students to develop mathematical problem-solving skills. Students tend not to get used to building their knowledge through practice questions. As a result, the knowledge gained by students is less meaningful and easily forgotten.

Because of students, mathematical problem-solving abilities are still lacking. This can be seen from the results of initial observations made by researchers about the level of problem-solving abilities. Based on the observations of researchers through interviews with mathematics subject teachers and students at State Junior High School 2 Kalibagor, Banyumas Regency, showed that the mathematical learning process that took place was still dominated by learning that did not involve the active role of students. The learning used is still teacher-centered and limited to information transfer, especially in the form of theoretical and mathematical equations. In reality, the students' problem-solving abilities are still far from expectations [14]. Therefore, the problem-solving ability is one of the goals to be achieved in the process of learning mathematics. To achieve these learning objectives, one alternative that the researchers were used is the Process Oriented Guided Inquiry Learning (POGIL) model.

POGIL a learning model developed suitable to the essence of science in enhancing science processing skill. POGIL is basically developed from the guided inquiry model which combine guided inquiry and cooperative approach [15]. The consideration in this research emphasizes the idea of POGIL provide a real experiment in developing student's processing skill and their scientific attitude in growing their thinking skill of creating scientific concept independently. Guided inquiry learning model has positive effects on developing students’ performance, this idea was strengthened [16]. POGIL had such characteristics to help students developing their processing skill and not necessarily dependent on the facility in class or laboratory [17]. POGIL learning model has three steps to accomplish, which are: exploration, concept formation, and application. In exploration, students do some activities like observing, experiment designing, collecting, checking, and analyzing data, also investigating and testing the hypothesis. While in concept formation, students are expected to critically think and analyze the concept formation. In application, students are involved in the application of new knowledge in exercising, problem-solving, or even research situation. Through this activity, students work in a team to build their understanding and apply it to the new concept they have [18]. Based on the description of the introduction described, the purpose of this study was to determine whether POGIL had an effect on students' mathematical problem-solving abilities.
2. Method
This study was quasi-experimental research that used a nonequivalent posttest-only control group design where aimed to compare the influence of POGIL model and the conventional model on the students’ mathematical problem-solving ability. The variables involved in this research were mathematical problem-solving abilities as an independent variable, and the POGIL model as a dependent variable. The research design can be seen in table 1.

Table 1. Research design.

| Class      | Treatment | Test |
|------------|-----------|------|
| Experimental | X         | T    |
| Control    | -         | T    |

Table 1 shows that the treatment given in the experimental class (X mark) where the researchers applied the POGIL model in the learning, while in the control class, the researchers did not apply the POGIL model in learning but applied conventional learning. Both of them given post-test (T mark). The population of this study was the students at seventh grade in State Junior High School 2 Kalibagor, Banyumas Regency, even semester in the school year 2017/2018. There are 8 classes with a total of 239 students. The sampling technique used in this study is Cluster Random Sampling which is selected by lottery. Cluster Random Sampling is a technique that used to select the sample of randomizing groups if the sample of the randomized groups (classes) from the population have homogeneous characteristics, it means there is no superior class [19]. There was selected seventh grade of class A as experimental with 30 students and seventh grade of class B as control class with 30 students.

The data of the research were collected using test. This test is used to measure students' mathematical problem-solving abilities. This test was validated by two mathematicians, then it was tested to a group of seventh-grade students to fulfill the validity and reliability criteria. The score of students' ability in solving mathematical problems is determined by using a rubric scoring made [20]. Mathematical problem-solving indicators used in the test is understanding the problem which includes identifying known data, and identifying the data being asked; planning a solution or choosing a model; carrying out calculations or problems solving; re-examine the correctness of the results or answers [21]. Furthermore, the data were analyzed by using t-test after conducting a series of normality and homogeneity tests.

3. Result and discussions
Based on the results of the post-test mathematical problem-solving abilities were obtained between the class whose used POGIL learning model (experimental class) and class whose used conventional learning model (control class) is presented in the following table.

Table 2. The descriptive statistics of the post-test students’ mathematical problem solving abilities on experimental class and control class.

| Descriptive Statistics | Experimental Class | Control Class |
|------------------------|--------------------|--------------|
| N                      | 30                 | 30           |
| Max                    | 85                 | 75           |
| Min                    | 50                 | 45           |
| Average                | 66.91              | 55.91        |
| Median                 | 67.5               | 55           |

From table 2, it can be seen clearly that the average score of the experimental class is higher than the average score of the control class. The average score of the experimental class is 66.91 and the average score of the control class is 55.91. Furthermore, the maximum, the minimum, and the median scores for the experimental class are higher than the control class. It means that overall the test results of students' mathematical problem-solving ability on the experimental class are better than the control class.
Table 3. Normality test of the post-test students' mathematical problem solving abilities on experimental class and control class.

| Class       | Kolmogorov-Smirnov | Shapiro-Wilks |
|-------------|---------------------|---------------|
|             | Statistic          | Df | Sig. | Statistic | Df | Sig. |
| Experimental| 0.126               | 30 | 0.200| 0.967     | 30 | 0.449|
| Control     | 0.132               | 30 | 0.195| 0.945     | 30 | 0.122|

From table 3, it can be seen that significant value for the experimental class and the control class were 0.200 and 0.195 more than alpha 0.05 respectively, based on the Kolmogorov-Smirnov test. Moreover, the significant value for the experimental class and the control class were 0.449 and 0.122 more than alpha 0.05 respectively, based on the Shapiro-Wilks test. It means that both the experimental class and the control class fulfilled the assumption of normality test.

Table 4. Independent sample t-test of the post-test students' mathematical problem solving abilities.

| Levene's Test for Equality of Variances | t-test for Equality of Means |
|----------------------------------------|------------------------------|
| F  | Sig. | T | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference |
|----|------|---|----|-----------------|-----------------|-----------------------|----------------------------------------|
|    |      |   |    |                 |                 |                       | Lower | Upper |
| Equal variances assumed | 0.202 | 0.655 | 4.918 | 58 | 0.000 | 11 | 2.2366 | 6.5230 | 15.4770 |
| Equal variances not assumed | 4.918 | 57.345 | 0.000 | 11 | 2.2366 | 6.5219 | 15.4781 |

The summary of the hypothesis testing, with the help of SPSS program, is presented from table 4. Using Levene's test for equality of variances obtained significant value 0.655 more than alpha 0.05. It means that the result of post-test students' mathematical problem solving abilities fulfilled assumption of homogeneity test.

After conducting a series of normality and homogeneity tests, it was concluded that t-test for equality of means was used for hypothesis testing. From table 4, it can be seen the test results show that a significant value = 0.000 less than alpha 0.05. So that H₀ is rejected, it means that students' mathematical problem-solving ability taught by using POGIL model is better than students' mathematical problem-solving ability taught by conventional learning. In other words, POGIL model influences or effects on students' mathematical problem-solving abilities.

This research can be used for the teacher as an alternative learning model to improve students' mathematical problem-solving abilities in the class. From the next future research, it can determine whether the POGIL model will have an effect on students' mathematical High Order Thinking Skills (HOTS).

4. Conclusion

Based on the results of research conducted the students at seventh grade in State Junior High School 2 Kalibagor, Banyumas Regency. It can be concluded that students' mathematical problem-solving ability taught by using POGIL model is better than students' mathematical problem-solving ability taught by conventional learning. In other words, POGIL model influences or effects on students' mathematical problem-solving abilities.

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