The effect of process oriented guided inquiry learning (POGIL) model toward students’ logical thinking ability in mathematics

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Abstract. The ability of thinking logically needs to be developed due to the fact that it is an essential basic skill. But, the facts showed that students’ logical thinking ability in mathematics still low. The aims of this research is to investigate the effect of Process Oriented Guided Inquiry Learning (POGIL) model toward the students’ logical thinking ability in mathematics. This research was conducted at one of Junior High School in Indonesia. In this research we set up a Quasi experimental design. The experimental groups were taught by Process Oriented Guided Inquiry Learning (POGIL) Model. The control group was taught in a conventional learning model. The population of this research are students from seventh grade. The sample of this research are 49 students, which consists of 24 students in experimental group and 25 students in control group. The results showed that students’ logical thinking ability in mathematics which taught by Process Oriented Guided Inquiry Learning model are better than the students which taught by conventional learning model. Process Oriented Guided Inquiry Learning Model can be applied as the innovative learning process to increase students’ logical thinking ability in mathematics.

1. Introduction
Mathematics is one of subjects needed to learn at schooling in order to fulfill skillful students. It is important for them to pursue higher education, reaching their dreams, using it into daily life, and facing multi challenges life both simple and complex one. Logical thinking is a key to draw a conclusion and solving complex problems [1]. So that, logical thinking ability in mathematics is one goal of mathematics education that should be achieved.

Thinking logically is not a ‘magic’ process or genetically, but it’s a mental process that is being learned [2]. According to Siswono, logical thinking can be interpreted as the ability to make the right conclusion based on logical rule and proof that the conclusion is valid as the knowledge known before [3]. In the line, Suriasumantri stressed that logical thinking is the ability to find validity based on the logical way [4]. A student can be assumed that he/she thinking logic if she/he can explain the idea in the arranged words so that her/his argument can be valid [4]. Concern with Suriasumantri idea, Romauli explained that logical thinking is the activity based on norms and systematic rules so that it doesn’t contains any guiltiness and can produce the right conclusions [5]. Indicator logical thinking in this research are analogy, generalization, and make the direct proof.
Based on the explanations above, we knew that logical thinking is a key to draw a conclusion and solving complex problems, so that Logical thinking ability in mathematics should be enhanced. Many literatures recommend that teachers should develop students’ thinking skill through teaching, to support students to reflect their learning process. Interaction between individuals can support students to communicate and explain their thinking. Learning process in the class has to be designed so that it can serve various activities that provoke students’ thinking and students can control their own intellectual activities [1]. Learning model that hopefully can improve students’ logical thinking is POGIL (Process oriented Guided Inquiry Learning) model.

POGIL was adapted from methods used in chemistry classrooms at Franklin and Marshall College by Rick Moog, Jim Spencer, and John Farrell in the mid-1990’s [6]. Process Oriented Guided Inquiry Learning (POGIL) is a method combining guided inquiry and cooperative learning in learning process [7].

The activities in POGIL are based on the Learning Cycle Approach. The learning cycle used are as follows: Exploration. In this phase the students interrogate the information by exercises that given through discussion within their groups [8]. The exercises may involve the making of observations, the analysis of results or data, or even the design of an experiment. Students are to generate hypotheses and test them in order to explain and understand the information. In this phase of exploration, each student should work harmoniously with others to meet specific learning objectives [9]. Concept Invention. In this phase the students describe or explain the observations made while exploring. After the students have constructed and expressed their own understandings, conventional related terminology is introduced by the teacher [10]. Application. This phase of the learning cycle requires deductive reasoning skills since it relates the general concepts derived in the previous phase to new situations [9]. Application to new situations builds learner confidence and provides the opportunity to solve real world problems [11].

Based on the explanation above, we interested to investigate about “the effect of process oriented guided inquiry learning (POGIL) model toward students’ logical thinking ability in mathematics”. The aims of this research is to determine the effect of process oriented guided inquiry learning (POGIL) model toward students’ logical thinking ability in mathematics. Research question in this study: are students’ logical thinking ability in mathematics which taught by process oriented guided inquiry learning (POGIL) model better than the students which taught by conventional learning model?

2. Method
This research employed quasi-experimental research methods. This method has the control group, but not able to function fully to control external variables that affect the implementation of the experiment. Quasi-experimental research is research which is close to real trial where it is impossible to hold control or manipulate all relevant variables. Research design employed post-test only control design [12].

The population in this research were students of class VII in one of Junior high school in Lampung Tengah. The population in this research were 128 students. Sampling technique in this research employed purposive sampling, taking sampling technique based on certain consideration [13]. The sample in this research were 49 students. The sample consists of two classes, there were class VIIB which consist of 24 students as the experiment group and class VIID which consist of 25 students as the control group. In this design, the experimental and the control groups are administered a same post-test.

Experimental groups were instructed with POGIL, while control groups received conventional learning model. The research was conducted during 2017-2018 over eight meeting. The independent variable was instructional methods (POGIL model and conventional learning model). The dependent variables in this study were students’ logical thinking ability.

3. Result and discussion
This research was conducted at seventh grades at junior high school in Lampung Tengah. This group consists of five 12-13 year-old students with mixed ability and is considered to be representative of other groups. This research investigated about students’ logical thinking ability in mathematics which taught
by process oriented guided inquiry learning (POGIL) model and students’ logical thinking ability in mathematics which taught by conventional learning model.

The data of result students’ logical thinking ability in mathematics were obtained by posttest score from both of classes, the experiment class and control class. By investigating the various problem solving strategy that used by students to solve the question of logical thinking ability, here the sample of the student’s work of logical thinking question, shown at Figure 1.

From 49 students, just 7 students can solve the problems. In mean that just 14,28% that can answer the question correctly and 42 students can’t answer correctly. The sample student work is the question and answer for logical thinking questions, indicator analogy. Based on the question the students were expected to get the analogy based on the similarity process. As we knew that 1 square ($1^2$), 4 squares ($2^2$), 9 squares ($3^2$), 16 squares ($4^2$), so based on the similarity process we knew that the squares have the same pattern ($n^2$). The question mentioned that students have to determined 25 squares ($5^2$), so that the figure can be seen like the student work at Figure 1. After we got the figure, the total of black and white squares can be determined easily. Based on the students’ answer above, it can be said that the students able to make the analogy based on the similarity process.

This research was conducted for nine meetings. eight meetings were for treatment applied process oriented guided inquiry learning (pogil) model at experiment group and conventional learning model at control group. The last meeting was for doing post-test (test of logical thinking ability). Score of logical thinking ability can be seen at the Table 1.

Given some squares sized 2 cm arranged start from 1 square, 4 squares, 9 squares, and 16 squares. The squares coloured with black and white such as the figure bellow:

How many the total of black squares and white squares if it’s given 25 squares?

![Figure 1](image1.png)

**Figure 1.** Student’s work of logical thinking question.

**Table 1.** Score of logical thinking ability experiment class and control class.

| Class     | Ideal Score | $X_{max}$ | $X_{min}$ | Tendency Central |
|-----------|-------------|-----------|-----------|-----------------|
| Eksperimen| 100         | 96.25     | 53.75     | 80,694          |
| Control   | 100         | 91.25     | 55.00     | 74,779          |

Explanation:
- $X_{max}$ = score maximum;
- $X_{min}$ = score minimum;
- $X$ = Mean;
- $Me$ = Median;
- $Mo$ = Modus.
After we got the score of logical thinking ability, then we investigated the normality test and homogeneity test as the prerequisite test to choose which the statistics test will be used. Normality test in this research used Lilliefors method. The result of normality test of logical thinking ability both of experiment class and control class can be seen at the Table 2.

**Table 2.** The result of normalitas test of logical thinking ability.

| No. | Class     | L<sub>count</sub> | L<sub>table</sub> | Conclusions          |
|-----|-----------|-------------------|-------------------|----------------------|
| 1   | Eksperiment | 0.116             | 0.148             | Accepted H₀          |
| 2   | Control    | 0.121             | 0.152             | Accepted H₀          |

Based on the result of normality test of logical thinking ability at experiment class and control class we can see that L<sub>count</sub> ≤ L<sub>table</sub>, so we can conclude that H₀ accepted, it means that the sample has normal distribution. Homogenitas test in this research used Bartlett test. The result of homogenitas test of logical thinking at experiment class and control class can be explained as follows. Based on the computation, χ<sup>2</sup><sub>count</sub> ≤ χ<sup>2</sup><sub>table</sub>, so we can conclude that H₀ accepted, it mean that the sample was homogen. The data was normal and homogen, so that the we used statistical parametric test (t-test). T-test was used to investigate the effect of independent variable (process oriented guided inquiry learning (POGIL) and conventional learning model) towards dependent variables (logical thinking ability).

The result of t-test was t<sub>count</sub> = 2.266 and t<sub>table</sub> = 1.995. Based on that result, it can be seen that t<sub>count</sub> > t<sub>table</sub>, so we can conclude that H₀ rejected. It means that students’ logical thinking ability who obtained process oriented guided inquiry learning (POGIL) are better than students’ logical thinking ability who obtained conventional learning model.

Here are the factors that students’ logical thinking ability who obtained process oriented guided inquiry learning (POGIL) are better than students’ logical thinking ability who obtained conventional learning model:

- POGIL has two foundational elements. The first is that during the exploration phase, students must be presented with adequate and suitable information. This will ensure a proper foundation from which to build knowledge and understanding. Secondly, the guided questions must be composed and arrangement in such a way that all students arrive at the correct conclusions and the development of process-oriented skills is encouraged;
- Students in the POGIL section appeared to take full responsibility for their learning. It’s because of in a POGIL environment, the class set up in small groups of four to five persons that are assigned individual roles: manager, reflector/technician, recorder, and presenter. Each role comes with its own set of responsibilities;
- In POGIL class, students are guided to utilize the foundational knowledge by constructing their own understanding of the concept, so that it can be meaningful learning;
- In POGIL class, the teacher as the facilitator to guided students to build on the concepts their selves. This method is in contrast with standard textbook procedures, which introduce terms and definitions first, followed by examples that aid in the understanding of the term.

The result of this study are in line with Hanson [10]. Hanson [10] explained that in a POGIL classroom, students work in self-managed learning teams with the instructor acting as leader, facilitator, assessor, and evaluator. The groups report their findings to the larger class, reflect on their learning, and self-assess both content mastery and teamwork. Compared to traditional instruction, POGIL classrooms are characterized by a high level of activity, student discussions about the content, partnerships among students, and immediate feedback to the instructor about what students know and how they are thinking.

Sen [7] also support the result of this study. According to Sen’s result, POGIL has a positive effect on students’ alternative conceptions [7]. The results showed that after the intervention, students in experimental groups (POGIL) had less misconceptions and had gained a more significant improvement.
than the students in the control group (conventional learning model). Because, inquiry activities ensure the physical and mental participation of students in the learning process.

4. Conclusion
Based on the analysis and discussion of the results that have been described previously, we can conclude that students’ logical thinking ability who obtained process oriented guided inquiry learning (POGIL) model are better than students’ logical thinking who obtained conventional learning model. The suggestion of that conclusion are as follows. POGIL model has a big opportunity for improving students’ logical thinking ability and may be for other high level mathematical thinking. Thus, to improve students’ logical thinking ability, teacher should be creative to select and to adopt innovative teaching such as POGIL.

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