



The Effectiveness of Process-Oriented Guided Inquiry Learning to Improve Students' Analytical Thinking Skills on Excretory System Topic

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Abstract

Analytical thinking is a fundamental skill in education and which needs to be developed. This research would describe the effectiveness of process-oriented guided inquiry learning (POGIL) to improve students' analytical thinking skills on the topic of excretory system. This study used Research and Development (R&D) design. It was conducted on the 11th grade students of senior high school in Ngawi, East Java in 2017/2018 academic year with one group pre-test and post-test design. The data collection techniques used were validation, observation, and test. The data were analyzed descriptively, whereby the analysis result was tested with the Gain test. The result showed that the students' analytical thinking skills was significantly increased as stated by the N-gain score. In control class, there were 2 students (6.7%) whose N-gain score was in the low category, 25 students (83.3%) whose N-gain score was in the medium category, and 3 students (10%) whose N-gain score was in the high category. In the experimental class, there were 21 students (70%) who got N-gain score in the medium category, and 9 students (30%) who got N-gain score in the high category. The results of this research showed that the students analytical thinking skills were different after the implementation of POGIL method. Therefore, it could be concluded that the POGIL was effective to improve students' analytical thinking skills on the excretory system in senior high school. The information obtained from this research can be used as a tool to improve students' analytical thinking skills.

How to Cite

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INTRODUCTION

Analytical thinking is the ability to think logically, break down the things and recognize cause and effect (Amer, 2005). Analytical thinking skills are high order thinking skills for learning at school (Anderson & Krathwohl, 2001). These skills get little attention in the learning process at school (Elder & Paul, 2007). Analytical thinking skills must be developed as a foundation of education for many professions in developing countries because such skills are essentially fundamental skills needed in learning, and they give many benefits to the development of technology and knowledge. Analytical thinking skills today are required in any workplace, especially in the teaching profession at school (Sudibyo, *et al.*, 2016). This is because analytical thinking skills help students to get more information, visualize much knowledge and solve complex nowadays problems to change the trend in the world (Sittipon, 2017).

Analytical thinking skills become a necessity for every developing country to develop its future human resource to be able to know how to solve many problems, acquire creative thinking skills, know how to acquire knowledge from many sources, and learn alongside to construct the bodies of knowledge by themselves (Few, 2015). Therefore, analytical thinking skills are needed today to solve the problems around us (Jakus & Zubčić, 2014; Taleb, & Chadwick, 2016).

Biology is one of the learning subjects in senior high schools (Susilowati & Anam, 2017). Biology lesson requires the ability to think logically, break down concepts as well as explain about them. Most of the biology concepts are very difficult and related to the abstract things, so that the laboratory works are needed to construct those concepts (Roviati, *et al.*, 2017).

Common teaching and learning activities in the classroom do not train students' analytical thinking skills (Zulfah, & Aznam, 2018). The low analytical thinking skills would not develop the students' thinking skills. They tend to be trained to respond problems by memorizing, which does not develop their higher order thinking skills as revealed in the study conducted by Siahaan & Samsudin (2017).

Students higher order thinking skills can be improved through learning can be thought provoke student's thinking skills. POGIL (Process Oriented Guided Inquiry Learning) emphasizes on cooperative learning, students' teamwork and activity design that can build the conceptual understanding and skills development during

the learning process such as the process science, thinking skill, problem solving, communication skills, management. Besides, they also can build positive social attitudes and skills assessments to develop metacognitive knowledge (Hanson *et al.*, 2006). POGIL has been proven to increase the understanding of the concepts related to biology learning (Gale & Boisselle, 2015; Rege *et al.*, 2016). Active learning applies guided inquiry into the learning groups (Walker *et al.*, 2017; Perwitasari & Valeriana, 2016; Mitchell & Hiatt, 2015). This model could also develop the students' understanding. The questions they ask can be influenced of their analytical thinking, willingness to find the resolution of the problem, preparations of metacognition and responsibilities. When POGIL is actively involved in the class and the laboratory, the students will be guided to draw conclusions from analyzing the data. They have to work together to understand the concept as well as to solve the problem, and reflect on what they have learned in order to be able to improve it (Hanson, 2006).

Based on the explanation above, it can be seen that the implementation of POGIL in the area of biology-related lesson can be relevant to be applied by the teacher because it can serve not only the required theories but also practice in the laboratory. One of the topic that is appropriate for the application of POGIL is excretory system. The interview with the biology teacher revealed that the common learning material (worksheet) only contained a number of questions without any experimental activities. Based on the description, the researcher developed a biology learning material that can fulfill the criteria of validity, practicality, and effectiveness. The purpose of this research was to describe the efficacy of POGIL material to improve students' analytical thinking skills on the excretory system lesson.

The efforts to increase the active participation of students in the learning process, to develop a module based on process-oriented guided inquiry learning (POGIL) on the topic of excretory system. The module which developed was expected to support the learning process and to guide the students in doing their activities in classroom independently through structured activities and to increase students' analytical thinking skills.

METHODS

The subjects of this research were 60 students of 11th grade of 2017/2018 academic year in Ngawi, East Java. The subjects were chosen by

Simple Random Sampling to determine the control class (XI MIA 3) and the experimental class (XI MIA 1) with 30 students each. The development of learning material employed the Research and Development (R&D) design (Sukmadinata, 2015). The developed learning material in this research consisted of student worksheet and analytical thinking skills tests (Sukmadinata, 2015). The stages in research and development method included preliminary study and testing. The learning material developed in this research had passed the validity test resulted in the valid and very valid category.

This research had been conducted for five weeks, starting from April to May 2018 by employing pre-experimental research with one-group pretest-posttest design (Arikunto, 2010). The experimental design was used to investigate the effectiveness of POGIL on the students' analytical skills. The data of effectiveness were obtained from the test scores of the students' analytical thinking skills. Then, the data was analyzed descriptively. The scores of student's analytical thinking skills were categorized based on the following criteria: poor, average, good, and excellent (Riduwan, 2012).

Table 1. Criteria scores of students' analytical thinking skills

N-gain Score	Criteria
$3.25 < n \leq 4.00$	Excellent
$2.50 < n \leq 3.25$	Good
$1.75 < n \leq 2.50$	Average
$1.00 < n \leq 1.75$	Poor

The differences in the scores of students' analytical thinking skills before and after the treatment were analyzed by using N-gain test. The scores of N-gain test were categorized based on the following criteria: low, medium and high (Hake, 1998). The N-gain calculation data were then converted using the criteria in Table 2.

Table 2.Criteria of N-gain score

N-gain Score	Criteria
$0.7 < g$	High
$0.3 \leq g \leq 0.7$	Medium
$g \leq 0.3$	Low

RESULTS AND DISCUSSION

The students' pretest and posttest scores of the analytical thinking skill test in the control class

The students' analytical thinking skills were measured by a test instrument consisting of 30 multiple-choice questions. Figure 1 shows the scores of students' analytical thinking skill test and the increase of N-gain score. Figure 1 showed that students' analytical thinking skills (knowledge aspects) at the first (pretest) ranged in which 1 student was included in low category, 22 students were in good category, and 3 students were in excellent category. The results of the pretest and posttest were then analyzed by the N-gain score. There were 2 students (6.7%) whose N-gain score was in a low category, 25 students (83.3%) in the medium category, and 3 students (10%) in high category.

Student learning achievements can be increased by teachers through using many methods and media that can attract the students attention (Rosarina, *et al.*, 2016; Sutrisno & Siswanto 2016). There are various ways to execute innovation in education, such as by applying models, methods, strategies, even learning approaches that aim to make learning become more interesting for students (Marliyah, (2014); Maisaroh & Rostrieningasih, (2010); Mushtaq & Khan, (2012).

Student learning achievements become low caused by several factors including student learning motivation, learning media, facilities in laboratory and the teachers that have not find an exact way in building the students' understanding earlier (Yussia, *et al.*, (2016); Chen, *et al.*, (2009). From all the factors, the learning method chosen by the teachers is the most influential factor to the students' learning outcomes (Jeffrey & Zein, 2017).

The pretest and posttest scores (cognitive aspect) of of the analytical thinking skill test control class

The scores of pretest and posttest (cognitive aspect) of the control class were measured using a questionnaire consisting of 30 questions with 5 possible answers. Before the test, the instrument had been tested and validated by the validator.

Data in Figure 1 showed that the result of pretest and posttest then analyzed by N-gain score. In the control class there are 2 student (6.7%) got N-gain score got low category, 25 students (83.3%) got N-gain score in medium category, and 3 students (10%) got N-gain score in high category. The students' analytical thinking skills are significantly increasing which is stated by N-gain score. In the experimental class there are 9 students (30%) got N-gain score in high category, and 21 students (70%) got N-gain score in

medium category.

Data in Figure 1 showed that the average N-gain scores of the students in the control class is 0.50 in medium category. After the implementation of POGIL, that the average N-gain scores of the students in the experimental class is 0.60 included in medium category. So, the average N-gain scores of the students in the experimental class is higher than the average N-gain scores of the students in the control class. Therefore, POGIL you used is proven to successfully improve the students' analytical thinking skills. Visually, the difference of N-gain scores in the control class and experimental class is presented in the following Figure 1.

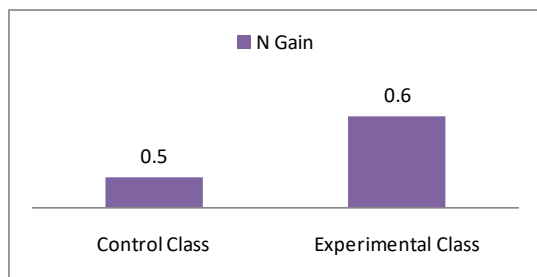


Figure 1. Histogram of Average N-gain of control class and N-gain of experimental class

Based on the analysis of the answer and interview to several students, it was found some factors that affect the results of n-gain score. The lack of lab works is one factor that influences learning outcomes as in biology learning the students must learn with experiment to solve many problems related their lives. Besides, he other influential factors are teamwork and skill. From the interview with several students, it was found that the students with the high category have excellent teamwork and good skill. This claim can be seen from the fact that the students are able to discuss with their group friends, analyze experimental result and formulate conclusion. The students in the medium category have low ability to identify the problem based on the phenomenon and to formulate conclusions.

The students' pretest and posttest scores of the analytical thinking skill test in the experimental class

Students' analytical thinking skills were measured by a test instrument consisting of 30 multiple-choice questions. Figure 3 below shows the scores of students' analytical thinking skills and the increase of N-gain score in the experimental class.

The high increase in N-gain score showed

that the implementation of the developed learning material through POGIL could improve students' analytical thinking skills. The increase of N-gain score occurred because the teacher could perform all phases of POGIL in good condition. Also, the learning steps in the lesson plan were developed with the syntax of the POGIL model which included five phases comprised of orientation, exploration, concept formatting, application and closing (Hanson, 2006).

The students' average scores on all the indicators of attitudes improved because they had been trained to use the scientific attitude through process-oriented guided inquiry learning activities using the scenario of classroom learning with biology materials, such as discussing with a group of friends in identifying problem-based phenomenon, making hypothesis, experimenting task, tabulating experimental data, analyzing experimental results, and formulating conclusions (Boleng *et al.*, 2018). In POGIL, there was a scientific process to answer the questions posed with scientific attitudes.

The scores of experimental class students' analytical thinking skills in cognitive aspect

The students' analytical thinking skills were measured using a questionnaire consisting of 30 questions with 5 possible answers. Before the test instrument was tested, the instrument had been validated in prior. The N-gain score scores of students' analytical thinking skills can be viewed in the Figure 2.

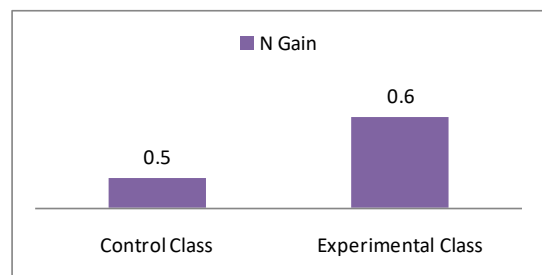


Figure 2. Histogram of Average N-gain of control class and N-gain of experimental class

Figure 2 showed that the result of pretest and posttest then analyzed by N-gain score. In the control class there are 2 student (6.7%) got N-gain score got low category, 25 students (83.3%) got N-gain score in medium category, and 3 students (10%) got N-gain score in high category. The students' analytical thinking skills are significantly increasing which is stated by N-gain score. In the experimental class there are 9 students (30%) got N-gain score in high category, and 21 students

(70%) got N-gain score in medium category.

The average N-gain scores of the students in the experimental class is higher than the average N-gain scores of the students in the control class. Therefore, POGIL you used is proven to successfully improve the students' analytical thinking skills

The analysis of the results of interview with several students found some factors that affect the N-gain score or the students' learning outcomes. Lab work is one factor that contributes to the students' low learning outcomes. Biology learning must be filled with activities that require the students to solve problems according to what they have to face in everyday life. Besides, the other factors that influence the learning outcomes are teamwork and skill. From the interview results with several students, the students of the high category have excellent teamwork and good skills. This has been observed that the students were able to discuss in their group, analyze the result of experiment and formulate the conclusion. The students in the medium category have low ability to identify the problem based on the phenomenon as well as to formulate the conclusion. The students stated that they still couldn't understand the question given and they were confused in solving the phenomenon.

These results are supported by Şen *et al.* (2015) that showed that POGIL can be used to enhance self-regulated learning skills of 11th grade students. Sartono & Handayani (2017) stated that biology learning through POGIL was better than conventional learning to increase students' analytical thinking skills in senior high schools. In addition, the study of Zamista & Kaniawati (2015) also found that POGIL is effective for improving science process skill and students' cognitive ability. It can be concluded that in science learning, POGIL has positive impacts on the students' science process skills and cognitive ability. The study conducted by Moore & Black (2015) found that POGIL gives the students experiences of critical thinking, problem-solving, and communicating as well as working in a team. Douglas & Chiu (2012) also mentioned that the implementation of POGIL will help the students make sense of their learning and increase their awareness of being active learners and provide them the opportunities for self-assessment of their learning. Furthermore, the results of this research are also supported by Geiger (2015) whose study revealed that the POGIL offers to promote a deeper learning for the students, encourage and increase their responsibility in learning, develop their process skills, and improve their satisfaction.

The information obtained from this research can be used as a tools to improve the students' analytical thinking skills. The results of this study can promote the development of similar learning material for other subjects or topics in order to improve the students' analytical thinking skills. The results of this research will help other researchers who want to develop POGIL learning to improve the students' analytical thinking skills.

CONCLUSION

Based on the results and discussion of this research, it can be concluded that the developed POGIL method is effective to be used in teaching and learning to improve the students' analytical thinking skills on excretory system topic. This is proven by the increase of N-gain score with the medium and high category. The N-gain score also indicates that the students' analytical thinking skills in the experimental class are higher than those in the control class. Thus, there is a positive impact of the implementation of developed POGIL method on the improvement of the cognitive aspects of analytical thinking skills in senior high school students.

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