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Effect of POGIL Learning Model toward Students' Critical Thinking Skills on Buffer Solution Material

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Abstract – One of the essential skills students should possess in the 2013 Curriculum is critical thinking. However, students' critical thinking skills in buffer solution material are considered low. Therefore, this study aims to identify the different critical thinking skills between students who attend a process-oriented guided oriented learning (POGIL) with and without science, environmental, technology, and society (SETS) approach on buffer solution material. This research uses quasi-experimental with a posttest-only control group design. The research results reveal that: (1) both POGIL learning models with and without the SETS approach are classified to be successfully carried out; (2) different critical thinking skills are found in students who learn using the POGIL learning model with and without the SETS approach on buffer solution material. The POGIL learning model with the SETS approach carries better students' critical skills results than the one with no SETS approach on the buffer solution material.

Keywords: critical thinking, POGIL, SETS approach, buffer solution

INTRODUCTION

In the 21st century, science, technology, and the economy have been developed rapidly. Consequently, students are demanded to actively learn more material to attain the knowledge and skills required to survive in this century. Critical thinking belongs to one of the skills demanded in 21st-century society (Hosnan, 2016). The significance of critical thinking skills is also accentuated within the currently used 2013 Curriculum. According to the Ministry of National Education Regulation NO. 81A Year 2013, the competencies being promoted in the 2013 Curriculum include creativity, curiosity, and critical thinking skills required to live smart and have lifelong learning. Besides, the standard competencies for primary and secondary school graduates mentioned in the 2013 Curriculum instructed students to have the ability to think and act critically, creatively, productively, independently, collaboratively, and communicatively (Kebudayaan, 2016).

According to (Ennis, 2011), critical thinking represents logical and reflective thinking that focuses on deciding what to be believed and done. Students with excellent critical thinking skills are expected to make a decision that resolves the problem. The interview results with students from 12th science class show that the learning processes on buffer solution material are dominated by lecturing, question, and answer, as well as completing the exercises on their chemistry textbook. As a consequence, students become passive during the learning process. Besides, the learning also rarely trains students to operate their critical thinking in processing the provided information and knowledge. The information obtained from one of the chemistry teachers in State Senior High School 1 Pandaan also reveals that only some students actively

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answer questions during the learning process on buffer solution materials. Further, the teacher also mentioned that those students were incapable of logically and adequately explaining the reasons for their answers. It indicates that students are unable to use their critical thinking skills properly.

Senior high school students' critical thinking skills need to be developed to enhance their fundamental conceptual comprehension so that they encounter no difficulties in understanding the materials. Critical thinking is a high order thinking skill with a role in science, social, cognitive, and moral advancement (Hashemi, Naderi, Shariatmadari, Naraghi, & Mehrabi, 2010). Students' excellent critical thinking skills aid them in the current and future learning process. Findings from a study show that students' critical thinking skills on buffer solution material are categorized as low, primarily on idea analysis, assumption identification, and deductive creation aspects (Merianti, 2016). Students' low critical thinking skills are generated from their minimum information or knowledge and teacher center learning that drives students to only memorize the material (Shakir, 2009). A modification on the learning strategy is required to improve students' critical thinking skills, primarily on buffer solution material.

Process-oriented guided inquiry learning or POGIL is a learning model that eases the inquiry learning process. It emphasizes the context and procedure related to applying students' conceptual understanding and critical thinking skills (Rustam, Ramdani, & Setijani, 2017). POGIL learning model consists of five learning stages, namely orientation, exploration, concept formation, application, and closure (Hanson, 2013). This learning requires students to complete guided-inquiry activities in a group, such as analyzing data, issues, texts, or examples, and giving critical respond to various questions (Hanson, 2013). This learning aids students to comprehend the material and train their critical thinking skills.

The results of a study conducted by (Irwanto, Rohaeti, & Prodjosantoso, 2018) demonstrate that POGIL implementation escalates students' critical thinking and problem-solving skills. However, some students' critical thinking skills indicators remain low after the implementation of POGIL. As discovered by (Subarkah & Winayah, 2015), that POGIL learning positively affects students' critical thinking skills, primarily on the identification, drawing conclusion, formulate the possible answer, and hypothesis conclusion indicators on the equilibrium solution material. However, the students are incapable of attaining all indicators of critical thinking skills. It indicates that another learning approach is needed to enhance students' critical thinking skills.

An approach that associates the learning material and environmental, technological, as well as societal issues, is required to adapt the context of buffer solution chemistry learning through POGIL learning and increase students' critical thinking skills. One of the approaches that conform to those requirements in the science, environment, technology, and society (SETS) approach. This approach regards the elements of science, environment, technology, and society; thereby, teachers can associate the scientific concepts within the material with technological advancement and the students' environmental or societal issue(Maimunah, 2016). Learning using the SETS approach encourages the students to critically evaluate the identified scientific problems, better understand the attained scientific knowledge, and evaluate scientific knowledge (Autieri, Amirshokoohi, & Kazempour, 2016). Students are expected to make a decision and behave based on critical thought and scientific explanations to resolve their problems. The POGIL learning model with the SETS approach is predicted to escalate students' critical thinking on buffer solution material effectively.

METHOD

This research uses a quasi-experimental method with a posttest-only control group design. The participants in this study were all 11th-grade science students in State Senior High School 1 Pandaan divided into six classes. The samples were decided using a simple random sampling technique. Through a lottery that was drawn twice, 11th Science 5 was chosen as experiment class 1 that learn using the POGIL learning model and SETH approach. At the same time, the 11th Science 6 class was decided to be the experiment class II that used the POGIL learning model.

This research involved two types of instruments, namely treatment and assessment instruments. The treatment instruments included syllabus, lesson plans, and students' worksheets. Meanwhile, the assessment instruments were a learning implementation observation sheet that was scored by one of the chemistry teachers in State Senior High School 1 Pandaan during the learning process and critical thinking skill test. The test consisted of ten essay items. The lesson plan, students' worksheet, and a critical thinking skill test had been validated before they were used. Besides, the critical thinking test had also been tried out to assure its reliability and items validity.

The obtained data subsisted of students' critical thinking scores on the buffer solution material. The data were analyzed using two types of analysis, statistical and descriptive analysis. The statistical analysis used in this study was a hypothesis test using the SPSS 16.0 program after the data normality and homogeneity had been tested using the same program. On the other hand, the descriptive analysis was carried out by calculating students' percentage on each critical thinking skill category. After that, the data were grouped into levels of critical thinking skills of very critical, critical, less critical, and poor critical. This study was conducted in State Senior High School 1 Pandaan from 11th to 24th February 2019.

RESULTS AND DISCUSSION

According to the percentage of learning process applications, both POGIL learning with and without SETS approach implementations are classified as excellent with more than 90% score. Students' critical thinking skills data on buffer solution material were obtained from the critical thinking test score, administered at the end of the learning process. The students' critical thinking score uses a 0-4 scale so that the maximum attained score is 40. Students' critical thinking scores for POGIL learning with and with no SETS approach are presented in Table 1.

Table 1. Summary of Students' Critical Thinking Scores

Class	N	$\bar{x}$	SD	Highest Score	Lowest Score	Critical Thinking Skills Percentage
POGIL with SETS approach	30	31,2	2,3	36	28	78,08%
POGIL	30	28,9	3,2	34	24	72,25%

Description:
N = total number of students
$\bar{x}$ = average score
SD = standard deviation

Table 1 reveals a higher students' critical thinking skills score from the POGIL learning model with the SETS approach than the one without the SETS approach. Consequently, it proves that the POGIL learning model with the SETS approach carries better students' critical thinking results than POGIL learning without the SETS approach on buffer solution material.

The number of students on each critical thinking skill category from both classes is shown in Table 2.

Table 2. Number of Students on Each Critical Thinking Skills Category from both Classes

Critical Thinking Skills Category	POGIL Class with SETS Approach		POGIL Class without SETS Approach	
	Number of Students	Percentage	Number of Students	Percentage
Very critical	9	30%	6	20%
Critical	21	70%	22	73,3%
Less Critical	0	0%	2	6,7%
Poorly critical	0	0%	0	0%

The data were analyzed using a one-tailed t-test through SPSS 16.0 program. Before that test, the required analysis of normality and homogeneity tests were also carried out. The test results confirm that the students' critical thinking skills on the buffer solution have a normal distribution and homogenous variation. The summary of the hypothesis test is presented in Table 3.

Table 3. Summary of Hypothesis Test Results

Variable	H_0 Test Result		Decision
Critical Thinking Skill	t_{count} =3,266 *sig.* = 0,002	H_0 rejected	H_1 = There is a difference between students' critical thinking skills attending POGIL learning with and without the SETS approach on buffer solution material.

The learning activities in both POGIL classes with and without the SETS approach have been excellently carried out. It is indicated by the average implementation percentage of POGIL class with the SETS approach (96.4%) and without the SETS approach (97.5%) from the first to the last meetings. However, some shortcomings of the POGIL learning model with and without the SETS approach are discovered.

The third and fourth meetings that discuss acid and base buffer solution's pH sub-material attains a 94% score of learning implementation. One learning stage was not scored by the observer, namely encouraging students to formulate problems and propose hypotheses. This happens due to the time limitation that causes the researcher to be hurried. Thus, in the third and fourth meetings, the students were directly proved with the hypothesis without an initial discussion on it. The fifth meeting that discusses the role of buffer solution sub-material also scores 94% of learning implementation. One of the learning activities in that meeting was not implemented, namely delivering information related to the next meeting's topic. It was caused by bad atrocious time management, and many students went out of the class to donate their blood so that the situation was uncontrollable. Those problems were resolved by giving the information related to the next meeting's topic outside the chemistry class period.

The third and fourth meeting that discusses acid and base buffer solution pH attains 93.75% of learning implementation. Checking students' attendance activity was not completed. It was caused by the reduced period for chemistry learning since students were not ready, while some of them still worked on the previous course's task. Meanwhile, in the fourth meeting, the learning period was also reduced because students were late since they needed time to go to the class after the physics class was held in the physics laboratory.

The hypothesis analysis result using an independent sample t-test reveals a significance value of 0,002 < 0,05, which indicates a difference between students learning in POGIL classes with and without the SETS approach. The students from the POGIL class with the SETS approach have a higher average critical thinking skill score (31.2) than students from the class with no SETS approach (28.9). Besides, a higher number of very critical categories are found in

the POGIL learning with the SETS approach than the one without the SETS approach. Further, 6.7% less critical students are also found in the POGIL class with no SETS approach, while there are no less critical and poorly critical students from POGIL class with the SETS approach. This confirms that the SETS approach aids students in understanding the material in chemistry learning better because the learning context adapted from students' daily life transforms the learning to be more meaningful. For instance, students learn buffer solution material by investigating the pH balance of baby shampoo, seawater, saliva, and stable human blood of 7.4.

In addition, the students who attend POGIL learning with the SETS approach are also trained to enhance their critical thinking skills. The different level of questions aims to improve students' critical thinking were provided in both classes. In the POGIL class with the SETS approach, students were trained to use their higher critical thinking skills by correlating the science material to their environment, technology, and society. Thus, they can logically answer the question and explains the reasons. The results of a study state that implementing the SETS approach in learning facilitates students to understand abstract chemical science (Mulyani, Ariani, & Nugraheni, 2013) and escalates their critical thinking skills. Additionally, (Nisak, Wartono, & Suwono, 2017) reports that guided-inquiry learning based on SETS is more useful to train students' critical thinking skills than the conventional guided-inquiry learning model. Meanwhile, the POGIL learning strategy combines guided-inquiry and cooperative learning; thus, students are actively involved in the group discussion during the learning process to construct their understanding (Maulidiawati, 2014).

The learning activities on both POGIL classes with and without the SETS approach involve students' active discussion in groups of 4-5 students to solve problems in the students' worksheet. Students in POGIL class with the SETS approach were provided a text of buffer solution phenomena or a problem found in their daily life on the orientation and application stages. Students were trained to actively discuss the relation of SETS elements (science, technology, environment, and society) on the provided text or video to attain information and practice their critical thinking skills in finding answers with logical reasons to the provided questions. One of the SETS characteristics mentioned by (Yager, Dogan, Hacieminoglu, & Yager, 2012) is students' active involvement in gaining information and resolving them. A learning strategy that presents students with opportunities to evaluate the given information and discuss the solution in a small group increases their critical thinking skills. Thus, this becomes a factor that generates different students' critical thinking skills from POGIL learnings with and without the SETS approach. In summary, POGIL learning with the SETS approach brings better students' critical thinking skills results on buffer solution material than POGIL learning without the SETS approach.

CONCLUSION

According to the data analysis results, the implementation of both POGIL learnings with and without the SETS approach is categorized as excellent. It is confirmed by the learning implementation percentage for POGIL learnings with and without the SETS approach of 96.4% and 97.5%, respectively.

The difference in students' critical thinking skills from POGIL classes with and without the SETS approach is found with a 0.002 significance value. With an average critical thinking score of 40, the students from POGIL learnings with and without the SETS approach obtain 31.2 and 28.9 average scores, respectively. Therefore, the POGIL learning model with the SETS approach brings better students' critical thinking skills result in the POGIL learning model without the SETS approach on buffer solution material.

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