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Implementation of the Process Oriented Guided Inquiry Learning With Socioscientific Issues of Environmental Pollution to Improve Student Scientific Literacy

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Abstract.
This study aimed to analyze the implementation of the Process Oriented Guided Inquiry Learning (POGIL) model with the Socioscientific Issues (SSI) of environmental pollution in an effort to improve students' scientific knowledge. The population in this research was 53 grade VII students at a junior high school in Bandung. The research used a quasi-experimental design with 24 multiple choice questions as the research instrument. The experimental group was taught through the POGIL model with the SSI context, while the control group was taught through a scientific approach. Based on data analysis, the n-gain category of scientific knowledge of the experimental class in content knowledge, procedural, and epistemic domains were dominant in the medium category of 50%, high of 46%, and high of 73%. The n-gain category of the control class in content knowledge, procedural, and epistemic domains was dominant in the low category of 52%, low of 41% and high of 67%. The result obtained from the t-test on normal and homogenous data showed that there was a significant difference. Based on the data analysis, the scientific literacy skill of students who received POGIL with SSI was better than students who received the scientific approach, and the attainment of students' scientific knowledge domains was in the high category.

Keywords: implementation, inquiry learning, socioscientific issues, environmental pollution, student Literacy

1. INTRODUCTION

The rapid development of science and technology in the Globalization Era is basically intended to help and benefit people in the world in various aspects of life, but over time it turns out that negative impacts have also emerged such as environmental damage, environmental pollution, and others. Scientists who are concern about the environment and the future of the earth are starting to think about how to prevent and overcome the negative impacts of the complex development of globalization, one of which is through education. For example, the United Nations (UN) through UNESCO-ICASE formulated scientific literacy and technological literacy [1]. The World Economic Forum [2] explains that in the world of education, students need learning in addition to content that also emphasizes skills and abilities in order to keep pace with the swift currents of globalization in the 21st century, one of which is scientific literacy skills which is one of the 16 skills needed in 21st century. There are several views of scientists about the importance of scientific literacy, Yore [3] suggests that one of the main issues that must be built or developed is the view of scientific literacy, Fouzder and Markwik [4] states that educating people to have scientific literacy is the main goal in any educational reform in science, scientific literacy has become an internationally recognized educational goal and learning about scientific literacy is one of the important topics in science education [5]. Scientific literacy is a person's ability to engage with issues and ideas related to science, willing to engage in discussions about science and technology, and able to explain scientific phenomena [6]. Someone who has scientific literacy skills also has a desire to evaluate and design scientific investigations, interpret data and evidence scientifically, analyze and evaluate data, claims, and arguments [7]. World Economic Forum [2] states that scientific literacy is the ability to use knowledge, the basis for understand about the environment and the basis for testing hypotheses.

Science learning is one of the important subjects in the Senior High School Curriculum in Indonesia. Science learning which aims to develop scientific literacy must be well designed so that learning objectives can be achieved. Hand, Lawrence, and Yore [8] emphasized that before teaching scientific literacy, teachers must use appropriate learning strategies. One of the science learning strategies is the application of student-centered learning. Isjoni & LN [9] states that conversion based Teacher-Centered Learning (TCL) toward Student-Center Learning (SCL) is one of the efforts to answer the challenges of globalization that requires community graduates who are professionally competent. One of the student-centered learning models is POGIL or Process-Oriented Guided Inquiry Learning. POGIL has seven learning stages called the Learning Research Process, namely: Identification of the need for learning, linking previous knowledge, Exploration, Understanding and concept formation, Practice applying knowledge, Applying Knowledge to new concepts, Reflection in processes [10]. The characteristics of POGIL are that the teacher is a facilitator, and there are differences in the role of students when working in teams, namely: manager, reflector, scriber, and presenter

[11]. The advantages of POGIL are supported by several previous research results [12] compared PBL (Problem Based Learning), PLTL (Peer-led Team Learning) and POGIL and proved that POGIL can improve student performance and grades. Conducted a study applying POGIL learning and compared to the usual method, got the results that the average final score of students increased compared to the usual method and the role structure in the POGIL model discussion group fosters a sense of responsibility in students in completing the tasks assigned by the teacher.

Science learning that use to build and optimize scientific literacy will be more meaningful if the teaching is associated with a context that is closely related to scientific literacy, that is Socioscientific Issues (SSI) context. Scientific literacy will be built with the help of the SSI context and can promote the nature of science, and the application of the context of Socioscientific Issues in science learning has another important role, namely sufficient for students to become someone who is higher order thinking (HOT), has discussion skills, and argues about science and inquiry. Research conducted by Hand, Lawrence and Yore [8] concluded that students can be trained in their scientific literacy skills by asking students to do the task of creating and analyzing news articles or issues in everyday life related to science, by creating and analyzing articles. News related to science issues, students will build their own reasoning. The topic chosen in this research is environmental pollution. This topic was chosen because it is considered more contextual and the phenomena are easier to find by students in their daily lives. In addition, one of the topics discussed by PISA is about environmental pollution, the students will have a deeper knowledge about environmental pollution. It is very important to raise students' awareness of the importance of protecting the environment including water, air and land environments, which is integrated into students as a preventive step in dealing with the environmental pollution issues or phenomena that occur.

Teaching the topic of environmental pollution to students using the POGIL model with Socioscientific Issues context has the potential to improve students' scientific understanding about aspects of scientific knowledge better than using conventional learning. Based on the above explanation, the purpose of this study is to identify students ability in scientific knowledge aspect of scientific literacy through Process Oriented Guided Inquiry Learning (POGIL) model with Socioscientific Issues (SSI) context on environmental pollution topic. In addition, the POGIL model can be used as an alternative for teachers in implementing integrated science learning in the classroom to make it more diverse, especially to improve students' scientific literacy in aspects of scientific knowledge, and can be taken into consideration for other researchers in compiling POGIL learning with *SSI* context in developing student's science literacy skills.

2. RESEARCH METHOD

This study used a quasi-experimental method, the research design is a non-equivalent pretest-posttest control-group design with using two classes, namely the experimental class and the control class. This design is used to find out the difference between the class that are taught the POGIL model with SSI context compared to the class that are usually used by teachers in school, namely the scientific approach. The population in this study were all seventh grade students in one of the junior high schools in Bandung for the 2018/2019 academic year which were spread over ten classes. The sample selection technique used was cluster random sampling technique, and two classes were selected as the research sample with a total of 53 students. The instrument used in this study is multiple choice with 24 questions items that were used to obtain students' scientific literacy data on aspect of scientific knowledge which have three indicators namely content,procedural, and epistemic. The data were analyzed by using normality test (Kolmogorov-Smirnov test), homogeneity test (Levene test) and test of hypothesis by using t-test with software of IBM SPSS 24.00.

3. RESULTS AND DISCUSSION

Students' scientific literacy skills in the aspect of scientific knowledge were measured using multiple choice test questions consisting of 24 test items and were carried out 2 times, namely before treatment and after treatment. The results of the pretest and posttest of the two classes then carried out prerequisite tests, namely normality and homogeneity before testing the hypothesis. The pretest normality test was carried out with using of IBM SPSS 24 software, namely the Kolmogorov-Smirnov test with a confidence level of 95% or a significance value of 0.05, the homogeneity test was carried out with the Levene test. If the data normal and homogeneous, then continue with hypothesis testing using the t-test. The results of the normality and homogeneity, and hypothesis of pretest and posttest of the two classes shown in Table 1.

Based on Table 1, the results of the normality test show that the pretest sig value > (0.05) so it can be concluded that the data is normally distributed, and the data from the pretest homogeneity test of the science knowledge aspect shows that the pretest sig value and the posttest sig value > (0 0.05) so it can be concluded that the data of

Table 1: Results of normality, homogeneity, and hypothesis test of pretest and posttest.

Data	**Class**	**Normality (Kolmogorov-Smirnov[a])**		**Homogeneity (Levene Test)**		**Hypothesis Test (t-test)**	
		Sig.	**Conclusion**	**Sig**	**Conclusion**	**Sig.**	**Conclusion**
Pretest	Experimental	0.20	Normal	0.062	Homogeneous	0.72	No significant differences
	Control	0.23	Normal				
Posttest	Experimental	0.20	Normal	0.11	Homogeneous	0.018	Significant differences
	Control	0.20	Normal				

the two classes in the pretest is homogeneous, which means that the research subjects in the experimental class and control class have the same ability or homogeneous variance. Then, a parametric statistical test is performed using the t-test, with the aim of knowing whether or not there was a difference in the results of the pretest between the experimental class and the control class. The results obtained with p-value or sig > (0.05) means that before being given treatment to the two classes, the abilities of the two classes were the same or not significantly different. Furthermore, hypothesis testing was conducted on the posttest results of students' scientific literacy skills in the aspect of scientific knowledge. The test on this posttest aims to see whether the final results of students after being applied to different treatments or not.

Based on Table 1 for the posttest, the results of the normality test show that the posttest sig value is > (0.05) or normal, and the posttest homogeneity test results show that the posttest sig value > (0.05) or homogeneous, so it can be concluded that the research subjects in the experimental class and control class have the same ability or homogeneous variance. The next stage, after obtaining data that is normally distributed and has homogeneous variance, then the experimental class and control class are carried out parametric statistical tests using t-test. Based on Table 2, the results of the posttest t-test on aspects of scientific competence that have been carried out show that the second final ability shows a significant difference, as evidenced by the p-value or sig < (0.05). This means, after being given treatment to the two classes, the abilities of the two classes are significantly different. The recapitulation of the mean scores for the pretest, posttest and N-gain of students in the aspect of science knowledge in the experimental class and control class is presented in Table 3.

Scientific literacy skills in the knowledge aspect were analyzed based on three domains of science knowledge according to PISA 2015 [7] namely: 1) knowledge of science content, 2) epistemic knowledge, and 3) procedural knowledge. The scientific knowledge aspect in this research consists of content knowledge about water pollution,

TABLE 2: Recapitulation of the average score for pretest, posttest and N-gain the scientific knowledge.

Indicators of Scientific Knowledge	Pretest		Posttest		N-Gain	
	Exsperimental Class	Control Class	Exsperimental Class	Control Class	Exsperimental Class	Control Class
Content	51.05	55.5	79	70.3	0.57	0.33
Procedural	44.50	42.3	76.9	65	0.58	0.39
Epistemic	46.79	46.9	85.9	82.1	0.73	0.66

soil pollution and air pollution, which are also closely related to the context contained in PISA 2015 [7]. Based on the data in Table 2, the results of the average pretest aspect of scientific knowledge between the experimental class and the control class show that the pretest scores of the two classes are not much different, namely on each domain of scientific knowledge, this shows that before being given treatment the POGIL model with SSI context in experiments class and scientific approach learning in the control class, initial ability of the two classes are not significantly different. After being given different learning treatments in the two classes, the average percentage of posttest of each domain science knowledge in the experimental class had a higher score than the control class. The average value of n-gain of the two classes is also different in different categories. The n-gain categories and percentages are shown in the following table. Table 3 bellow describes the number of students based on the n-gain category in the content, procedural and epistemic knowledge domains of the experimental class and control class.

TABLE 3: Total of students by n-gain category in content, procedural and epistemic knowledge domains.

	Experimental Class			Control Class		
Knowledge Domains	N-gain Category	Total of Student	Percentages	N-gain Category	Total of Student	Percentages
Content	High	8	31%	High	6	22%
	Medium	13	50%	Medium	7	26%
	Low	5	19%	Low	14	52%
Procedural	High	12	46%	High	10	37%
	Medium	11	42%	Medium	6	22%
	Low	3	12%	Low	11	41%
Epistemic	High	19	73%	High	18	67%
	Medium	5	19%	Medium	4	15%
	Low	2	8%	Low	5	18%

There are 11 questions that measure content domain, and based on Table 3 the highest n-gain achievement in the experimental class is in the medium category, which is 50% of the total number of students, while the dominant control class can only achieve n-gain in the low category, which is 52% of the total number of students. Thus, for the content knowledge domain, students in the experimental class have better n-gain achievements than the control class. The high increase in content indicators in the experimental class indicates that students are able to understand science content related to learning the theme of water pollution, air pollution and soil pollution. In the experimental class there are some students who are low in increasing science content, because students have never been in or absent from class during learning and there are also students who are indeed low in learning interest, this can be seen during learning activities in class, students play around and often get permission to leave the class. While the dominant control class can only achieve n-gain in the low category, which is 52% of the total number of students, because scientific approach learning does not have typical learning steps such as POGIL, students are not given a context that is close to students' daily lives such as news or articles containing a scientific phenomenon and issue, and does not have the typical division of tasks or roles like the POGIL model which of course helps students understand science content. Beneteau, et al., [13] stated that POGIL learning provides students with opportunities to explore the concepts of the material they are learning and with structured POGIL learning guides students to understand the lesson content. This is in line with research conducted by Straumanis & Simon [14] that the characteristics of POGIL such as the division of roles in helping students learn learning content so that the average value of students' understanding of learning content in classes that apply POGIL is higher than teaching method.

There are 7 questions that measure procedural domain, the highest n-gain achievement category in the experimental class is the high category, which is 46% of the total number of students, while the dominant control class can only achieve n-gain in the low category, which is 41% of the total number of students. Thus, for the procedural knowledge domain, students in the experimental class also had better N-gain achievements than the control class. The high achievement of this procedural knowledge in the experimental class indicates that students have been able to interpret research data, analyze research data, and are able to design a research plan as a solution to a problem. Students are able to determine their own answers from discussions without depending on the teacher after students have explored [13].

Some of the reasons for the low n-gain of students on procedural knowledge both in the control class and some students in the experimental class, because students are not used to doing practical activities in the laboratory, students are not accustomed to being trained to read tables and examine research results. This can be seen from the first meeting, many students still ask the teacher about how to write a research problem formulation, research hypotheses, practicum steps and how to fill in tables based on the results of the practicum. A sizable increase in the experimental class applied by the POGIL model with the SSI context can be analyzed from the learning activities, which are supported by the existence of a third cycle, namely students doing practicum or investigation independently without much guidance from the teacher, the fourth cycle of the POGIL model is understanding and concept formation, at this cycle students present the results of the practicum and discussion results and the teacher confirms if there are erroneous concepts, and the fifth cycle is the practice of applying knowledge, at this cycle students are given the opportunity to apply their newfound knowledge to problems or issues related to the topic.

In the fifth cycle students analyze articles in the SSI context, which aims to link learning content with the context of students' daily lives, especially about environmental pollution materials, and students are trained to design processes for preventing the impact of environmental pollution and ways to reduce environmental pollution. Meanwhile, in the control class that uses a scientific approach, this activity does not exist. The SSI context used in the experimental class has a major influence in training students' scientific literacy, and this is in accordance with the opinion of Calik & Coll [15] that SSI-based news articles containing issues and phenomena related to scientific literacy make students enthusiastic in listening to learning, which meaning that SSI can help introduce scientific literacy to students, and the opinion of Nuangchalarm which states that the Sociocentric Issues article very good for supporting students' scientific literacy more deeply.

There are 6 questions that measure epistemic domain with the result that the highest N-gain achievement in the experimental class and control class in the epistemic domain is in the high category, but the percentage is higher in the experimental class, which is 73% while the control class is 67% of the total number of students. The achievement of n-gain in the epistemic domain is in the high category in both classes but the percentage is higher in the experimental class than the control class. This high epistemic knowledge indicates that students have been able to analyze and study an event so that students automatically get a scientific explanation [7]. Improving students' scientific literacy skills in experimental class science knowledge related to water pollution, air pollution and soil pollution, of course cannot be separated from the context of the Socioscientific Issues that are included in the POGIL model learning cycle, such as being given news videos, news images, and an issue of problems contained in the LKS before doing research, and the task of analyzing news articles in the fifth cycle of the POGIL model, namely the practice stage of applying knowledge. This is in accordance with the results of the study by Hand, et al. [8] which concluded that students will develop their reasoning and scientific literacy skills when students analyze news articles or issues that related to science and their lives.

4. CONCLUSION

Based on the data above, students' scientific literacy in the aspect of science knowledge has improved better after the POGIL model with Socioscientific Issues context was applied to the experimental class compared to the control class which applied scientific approach learning. The highest increase was in epistemic indicator, followed by content and procedural indicators.

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