The Influence of Process Oriented Guided Inquiry Learning (POGIL) Model Assisted by Realia Media to Improve Scientific Literacy and Critical Thinking Skill of Primary School Students

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Abstract: This research aimed at analyzing the influence of 'Process Oriented Guided Inquiry Learning' model assisted by realia media, in which it was to improve the scientific literacy and critical thinking skill of primary school students, especially for the material of energy. This quasi-experiment research used single factor independent groups design. The research sample of this research were fourth grade students of SD Inpres Oeba 2 Kupang City, East Nusa Tenggara Province, of which students were in the academic year of 2019/2020. The technique of sample collection was carried out purposive sampling for 2 classes. The IVA class was used as the experimental class (POGIL model assisted by the realia media), in which it consisted of 30 students and the IVB class was used as the control class (expository learning) that consisted of 28 students. The learning was carried out in four meetings. The data of scientific literacy and the results test of critical thinking were collected by means of objective test on the energy material. Multivariate Analysis of Variance (MANOVA) was used to analyze the data using significance level of 0.05. The results indicate that (1) There is a significant difference between the students' scientific literacy who gain the POGIL learning assisted by the realia media and the students' scientific literacy who get the expository learning; and (2) There is a significant difference between the critical thinking of students who get POGIL learning assisted by realia media and the students who get the expository learning. It can be concluded that there is a significant difference between the scientific literacy and the students' critical thinking taught by the POGIL learning that assisted by realia media to the students who use expository learning. Since there is a significant difference, it means that the POGIL learning assisted by realia media has an influence on the students' scientific literacy and critical thinking.

Keywords: *POGIL, process oriented guided inquiry learning, realia media, scientific literacy, critical thinking.*

Introduction

Science is considered as one of important subject matters in education which necessary to be taught from the lowest level of education, namely primary school (Braund & Reiss, 2019; Curran & Kitchin, 2019; Darling-Hammond et al., 2020; Faisal & Martin, 2019). Primary school is assumed as the beginning of education processes (Ferraz & Neves, 2017; Jacob & Rockoff, 2011). Consequently, it is required a learning which able to prepare the students in gaining adequate understanding of science (known as scientific literacy) (Prasasti & Listiani, 2019; Rochman et al., 2019; Sujana et al., 2019; Vieira & Tenreiro-Vieira, 2016), and having skills to live in the 21st century (Husamah et al., 2018; Yayuk & Husamah, 2020), i.e. critical thinking (Florea & Hurjui, 2015; Kettler, 2014; Vieira & Tenreiro-Vieira, 2016). The purpose of science learning in the primary schools is not to make the students for being expert in science, but rather to make the students understand and have scientific literacy (Fitzgerald & Smith, 2016; Laursen et al., 2007; Winarni et al., 2020).

Scientific literacy is very important to be possessed by the students (Calado, 2013; Joseph, 2012). An individual who has scientific literacy will use the owned skill in solving problems of life as well as creating scientific products that are useful (Labov, 2006; Rahayu, 2017; Turiman et al., 2012). The scientific literacy will be a provision for students in facing up complex global challenges (Hurd, 1998; Knain, 2015; Meldawati, 2017; Murnane et al., 2012). Meanwhile,

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critical thinking reinforces the students for being strong problem solvers (Amin et al., 2020; Saputro et al., 2020), impeccable decision makers and people who never stop learning (Florea & Hurjui, 2015; Moon, 2007; Ricketts, 2003). The critical thinking is also very important to be owned by each person (Hasan et al., 2019; Hayati & Berlianti, 2020; Maryuningsih et al., 2020; Permana et al., 2019). It encourages someone to solve the problems based on persuasive, logical, and rational arguments which involve of verification, evaluation, and choosing the right answers or even refusing through appropriate reasons and giving alternative solutions (Facione, 2011; Fitzgerald & Smith, 2016; Johnson, 2012; Storey, 2013).

Nevertheless, the data indicate that the Indonesian students' scientific literacy skill is still below average compared to other countries. The Programme for International Student Assessment (PISA) survey results in 2018 revealed that Indonesia's ranking was ranked 73 out of 79 countries with a score of 396 in the sector of science. This indicated that the science and technology abilities of Indonesian students are categorized as very low (Avvisati et al., 2018). In relation to the low capacity of scientific literacy at the national level, this also occurs in East Nusa Tenggara province, especially in Kupang city (capital of the province). One of schools that need attention to be investigated is the *Sekolah Dasar* (SD) Inpres Oeba 2 Kupang City (Primary School), East Nusa Tenggara Province. This is based on a recommendation from the education department of Kupang City and this school is one of our institutional partners (University of Muhammadiyah Kupang). According to the observation results in IVA class, on the academic year of 2019/2020, the science learning outcomes are low. There are only 12 (40%) students who are complete, while 18 students (60%) are incomplete due to their scores that are less than the Minimum Completeness Criteria, in which the criteria are 65. Temporarily, the students' critical thinking skill is very low, in which it is known from the data as well. The teachers also have not maximized the use of media and tend to be teacher-centered. The observational findings data indicate the existence of problems in the science learning processes.

In line with the demands about the urgency of developing aspects of scientific literacy and students' critical thinking abilities, it is required an implementation of learning model and learning media that in accordance with the purpose and characteristics of science learning. By using the model and learning media of subject matter delivered, it will ease the students in receiving and recognizing. Subsequently, Process Oriented Guided Inquiry Learning (POGIL) model is a potential model- in line with various previous studies which combined with the implementation of realia media.

POGIL is a research-based learning philosophy and methodology that is based on current understanding of how students learn in the best way (Hu & Shepherd, 2014; Moog & Spencer, 2008). The POGIL is based on constructivist principles that enable the students to learn through group interactions - consisting of 3-5 students (Kussmaul, 2014) and problem-solving activities (Hu & Kussmaul, 2012; Mitchell & Hiatt, 2010). Since POGIL method is different from other inquiry-based methods, the researchers decide to choose this model. Moreover, the learning activities are oriented to the process of gaining concepts, in which it is more constructive and interactive, and each student has a role and their respective contributions to catch on the concept, as confirmed by previous researchers, for example Irwanto et al (2018) and Moog et al (2006).

The POGIL model can be clustered into three elements i.e. "learning cycle based activities, use of self–managed class groups, and use of specific roles for group members" (Libby, 2008). Based on the Scopus database, POGIL has been implemented well in learning of college level and tends to give positive results (Hu & Kussmaul, 2012; Irwanto et al., 2018; Kussmaul et al., 2016; Moore et al., 2015; Roller & Zori, 2017; Vincent-Ruz et al., 2020; Williamson et al., 2013). The existence of POGIL implementation in the Senior High School level has been indicated in several researches (Devitri et al., 2019; Hu & Shepherd, 2014; Sen et al., 2016; Yuliastini et al., 2018). Yet there has not been any implementation of POGIL at the primary school level.

Furthermore, the realia media are all of real media existed in the nature or even "from the world outside the classroom that are used for teaching and learning" (Hadi, 2018), both used in a state of life or in accordance with the original or preserved, such as plants, rocks, animals, insectarium, herbarium, water, and so on (Y. D. Lestari, 2019). The use of realia media is deemed more effective due to the characteristics i.e. "memorable and enjoyable" for the students since they are facilitated to use their sense (Harmawan et al., 2019). The researchers decide to use Realia Media because this media can foster direct interaction between students and the existing objects. Realia media can assist in learning processes so that the students are more active when observing and it can generate motivation and stimulate the students to learn.

Hitherto, in the Scopus database, there are only three studies related to the use of realia media, in which it is to improve the science learning outcomes (Lalian et al., 2019), to improve the quality of learning process in the middle schools (Maramis et al., 2019), as well as improving the teacher's professional development (Artika & Saputri, 2018). A number of studies conducted in the primary schools published in the Indonesian local journal expose that realia media are effective to be used in science learning (Budiasih et al., 2016; Irman, 2020; N. Lestari & Mustika, 2014; Y. D. Lestari, 2019; Setyaningsih et al., 2019), and mathematics learning as well (Afifah, 2019; Maramis et al., 2019; Sugiharti, 2018; Trisnawati & Kamsiyati, 2019), and English (Irawan, 2017; Wijayanti, 2016). Those studies are only concerned on the improvement of learning outcomes and learning quality. No studies have been concerned yet on the aspect development of scientific literacy and critical thinking skill of primary school students.

The implementation of POGIL assisted by realia media in science learning is the first time done in Indonesia, and it is very uncommon for international level (as far as search results for international publications). Thus, this research is a pioneer which can be pursued and developed by other researchers who have interest in a research on the primary school level. Nonetheless, a research on scientific literacy in the primary school level is limited on instructional intervention (Lee et al., 2005), the use of robotics (Cejka, 2006), the use of integrated approach (Cervetti et al., 2012), STEM learning (Rochman et al., 2019; Rokayah & Rochman, 2019), Guided experiments book based on SETS (Prasasti & Listiani, 2019), and the water cycle theme (Sujana et al., 2019). Whereas, researches about critical thinking in science learning of primary school level are on the implementation of Evocation, Realization of meaning, and Reflection step (Florea & Hurjui, 2015), Science Writing Heuristic approach in fifth grade (Hand et al., 2018), the implementation of digital game-based learning in fifth grade (Hussein & Ow, 2019), RADEC model in fourth grade (Satria & Sopandi, 2019), topic of water cycle in fifth grade (Syaodih et al., 2019), problem-based learning (Zuryanty et al., 2019), Lectora Inspire media assisted guided inquiry method in fifth grade (Reffiane et al., 2019), as well as STEM in fifth grade (Elfrida et al., 2019). Those various researches also become a basic that the aspect of critical thinking can already be developed and investigated on the high classes of primary school (fourth to sixth grade). There is only one research which combines scientific literacy and critical thinking on the context of science learning in sixth grade in an urban public school (Vieira & Tenreiro-Vieira, 2016).

Research Goal

In accordance to those background, this research aimed at analyzing the influence of POGIL model assisted by realia media to improve the scientific literacy and critical thinking of primary school students.

Methodology

Type of research and design

This research was a *quasi-experiment* research. *Single factor independent groups design* was used as the design of research. The experimental class and control class had similar characteristics such as in terms of student ages ranging from 9-10 years. However, in terms of literacy and students' critical thinking aspects were different if it was seen from the evaluation test results.

The hypotheses of this research covered up: 1) there is a significant difference between science literacy of students who get POGIL learning assisted by realia media and the science literacy of students who get the expository learning. 2) there is a significant difference between critical thinking of students who get POGIL learning assisted by realia media and the students who get the expository learning. 3) there is a significant difference on science literacy and critical thinking of students who are implemented with the POGIL learning assisted by realia media and the students who implement the expository learning.

Research Sample

This research was implemented in SD Inpres Oeba 2 Kupang City, East Nusa Tenggara (*NTT*), Indonesia on the academic year of 2019/2020. This school was chosen due to the Education Office's recommendation of Kupang City and the inter-agency collaboration. The sample collection technique used purposive sampling from two classes of fourth grade, namely IVA and IVB classes. The IVA class was considered as experimental class which consisted of 30 students and the IVB class was used as the control class; moreover, it consisted of 28 students. Both of the classes had similar characteristics, of which characteristics were aged around 9-10 years old and came from the Timor ethnic.

Variable and Research Procedure

This research covered up three variables including of learning by means of POGIL model assisted by realia media as the independent variable, while scientific literacy and critical thinking were considered as the dependent variables. The energy material was chosen for the learning. The learning implementation of POGIL model was adopted form the syntax that was generally accepted (Chase et al., 2013; De Gale & Boisselle, 2015; Moog et al., 2006), whereas the control class was given the expository learning. Furthermore, this learning was conducted in 4 meetings. In the experimental class, the researchers implemented the POGIL model using learning stages, namely exploration, concept discovery, and application. After those stages were implemented, then it was continued with self-evaluation where the students evaluated their learning processes.

Instruments and Data Analysis

The instruments used in this study were learning devices such as lesson plans (*RPP*), student worksheets (*IKS*), and test questions which were validated by the experts or validators. Overall, the results of the validation of learning devices carried out by the validator showed that the learning devices that had been prepared got an assessment that was generally said to be valid. Based on the results of the validation, the researcher applied the learning devices in this research. The learning implementation observation sheet instrument was used to ensure the learning that carried out

was in accordance with the syntax. Scientific literacy and critical thinking tests used objective tests (multiple choice), then it was validated using five criteria, namely test validation using two expert test tabulation matrices, item validation using the Biseral Point correlation formula, reliability using KR-20, difficulty level, and test difference power.

In the last meeting, the experimental class (POGIL method assisted by realia media) was compared with the control class (expository learning) to discover which one had a significant influence on scientific literacy and critical thinking. The research data concerned on the scientific literacy and the test results of critical thinking collected through the objective test instrument on the energy material. Then, the obtained data were analyzed using Multivariate Analysis of Variance (MANOVA), in which the significance level was 0.05 assisted by SPSS 22 for windows.

Before examining the hypothesis, it was required to conduct prerequisite test such as normality test of the data distribution, homogeneity test for variance, and correlation test between dependent variables using the *SPSS 22.0 for Windows*. Normality test results from all four groups exhibited significant scores on the data *Kolmogorov Smirnov>* 0.05; thus, the data were normally distributed. So, the homogeneity test could be conducted. This test used two approach i.e. Box'M and Levene tests.

The value of Hypothesis 1 was 0.385, which meant that there was a significant difference between the scientific literacy of students who got the POGIL learning assisted by realia media and the scientific literacy of students who got the expository learning. The value of Hypothesis 2 was 6,037, which meant that there was a significant difference between the critical thinking of students who got the POGIL learning assisted by realia media and students who got the expository learning. The value of Hypothesis 3 was 3,037, which meant that there was a significant difference in students' scientific literacy and critical thinking between students who were applied to POGIL assisted by realistic media compared to expository learning. Meanwhile, the correlation value between scientific literacy and critical thinking was 0.118.

Results

The whole data summary of students' scientific literacy and critical thinking for the experimental and control classes were elucidated on the Table 1.

Table 1. The Summary of Descriptive Statistical Analysis

	Scientific literacy		Critical thinking	
	Experimental Class	Control Class	Experimental Class	Control Class
Mean	76.07	72.86	82.43	72.36
Median	77.00	73.00	83.00	70.00
Variance	97.926	144.646	96.116	161.571
Std. Deviation	9.896	12.027	9.804	12.711

The calculation results of average scores for scientific literacy in the experimental class were revealed on the Table 2, in which it was 76.07 which tended to be higher than the control class that obtained the scores of 72.86. While the average scores of critical thinking in experimental class were 82.43 and it was categorized as higher than the control class that gained the scores of 72.36. Based on the Box'M test, the significant value of α was 0.476 > 0.05, while the results of Levene test of literacy data was 5.586 as well as the critical thinking was 3.979. Thus, it could be alleged that the data were homogeneous and there was no multicollinearity.

The Table 2 displayed the data processing results of statistical analysis using the SPSS 22.00 for windows program.

Table 2. The summary of test results of between-subject effects

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected	Scientific literacy	46.413[a]	1	46.413	.385	.538
Model	Critical thinking	800.333[b]	1	800.333	6.037	.018
Intercept	Scientific literacy	270600.333	1	270600.333	2244.223	.000
	Critical thinking	287432.653	1	287432.653	2168.053	.000
Method	Scientific literacy	46.413	1	46.413	.385	.538
	Critical thinking	800.333	1	800.333	6.037	.018
Error	Scientific literacy	5787.667	48	120.576		
	Critical thinking	6363.667	48	132.576		
Total	Scientific literacy	289188.000	50			
	Critical thinking	312926.000	50			
Corrected	Scientific literacy	5834.080	49			
Total	Critical thinking	7164.000	49			

Departing from the Table 2, it was obtained the results of F_{value} of 0.385, df =1 and sig < 0.05. Hence, the testing of H_0 was rejected and H_a was received; moreover, there was a significant difference between the students' scientific literacy who gained the POGIL learning assisted by the realia media and the students' scientific literacy who got an expository learning. Based on the Table 2, the F_{value} results were 6.037, df = 1 and sig <0.05. Then, the H_0 test was rejected and H_a was accepted. There was a significant difference between the critical thinking of students who got POGIL learning assisted by realia media and the students who got expository learning.

Here were the results of multivariate test that elucidated in the Table 3.

Table 3. The summary of multivariate test results

Effect		Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	.988	1988.071[b]	2.000	47.000	.000
	Wilks' Lambda	.012	1988.071[b]	2.000	47.000	.000
	Hotelling's Trace	84.599	1988.071[b]	2.000	47.000	.000
	Roy's Largest Root	84.599	1988.071[b]	2.000	47.000	.000
Method	Pillai's Trace	.114	3.037[b]	2.000	47.000	.057
	Wilks' Lambda	.886	3.037[b]	2.000	47.000	.057
	Hotelling's Trace	.129	3.037[b]	2.000	47.000	.057
	Roy's Largest Root	.129	3.037[b]	2.000	47.000	.057

Table 3 illustrated the results of F_{value} of *Pillai's Trace, Wilks' Lambda, Hotelling's Trace, dan Roy's Largest Root,* in which it was 3.037 with a level of sig <0.05. As a result, the H_0 test was rejected and H_a was accepted. The conclusion revealed that there was significant difference in scientific literacy and critical thinking between the students who applied POGIL assisted by realia media and the students who applied the expository learning.

Discussion

Theoretically, the POGIL model more directed the students to easily understand the learning material (Bénéteau et al., 2017; Bressette, 2008; Hu & Shepherd, 2014; Kim, 2018; Kussmaul et al., 2016; Muhammad & Purwanto, 2020; Rumain & Geliebter, 2020; Straumanis & Simons, 2008; Williamson et al., 2013) and the students could solve the problems given by the teacher through a teamwork (Eberlein et al., 2008; Kussmaul, 2012; Muhammad & Purwanto, 2020). A teamwork learning would make the students to more develop their thinking skill in the higher level (Muhammad & Purwanto, 2020; Rustam, Ramdani, & Sedijani, 2017), it was due to the students' roles that were more active and it made the learning processes more interesting (Kussmaul, 2014). Additionally, the learning using a POGIL model would actively motivate the students to get their knowledge (Yadav et al., 2019; Yuliastini et al., 2018); subsequently, the students became an independent person, skilled, had scientific abilities, and active in solving the problems based on the knowledge gained (Hu & Kussmaul, 2012; Natalina et al., 2013; Vincent-Ruz et al., 2020).

Accordingly, the use of realia media in learning to support the POGIL made the students felt happy in the learning processes. This was because the students got an opportunity to directly investigated the real objects related to the material so that the learning felt fun (Budiasih et al., 2016; Puspaardini et al., 2019). The realia media used in learning processes could emerge the students' enthusiasm for learning (Budiasih et al., 2016; Habibah & Wardhani, 2019; Irman, 2020; Ismiyanti, 2015; Y. D. Lestari, 2019; Muslikah, 2017; Wijayanti, 2016), the learning processes became fun since the students directly established the objects in their environment (Habibah & Wardhani, 2019; Ismiyanti, 2015; N. Lestari & Mustika, 2014; Y. D. Lestari, 2019; Ramdani, 2017; Setyaningsih et al., 2019; Sugiharti, 2018; Sunarko & Hafsah, 2018). Whereas on the expository learning, the students were not given an opportunity to work in group. The students fully gained the knowledge from the teacher and could not find out on their own based on their abilities.

Referring to the results of data analysis explained from a theoretical point of view, the POGIL model was a model that made the students more active to work in teams, the students were able to solve the problems and had critical thinking abilities (Douglas & Chiu, 2013; Irwanto et al., 2018; Kussmaul et al., 2016; Lotlikar & Wagh, 2017; Moore et al., 2015; Roller & Zori, 2017; Straumanis & Simons, 2008; Vincent-Ruz et al., 2020). This was because the POGIL model was student-centered. The students were given the opportunity to catch on their own answers to each problem given through teamwork and guided inquiry activities (Douglas & Chiu, 2013; Kim, 2018; Kussmaul, Mayfield, & Hu, 2017; Moog & Spencer, 2008; Vincent-Ruz et al., 2020). In the POGIL learning processes, the teacher only acted as an instructor-facilitator-assessor-evaluator (Andriani, Nurlaelah, & Yulianti, 2019). During the learning processes, the teacher created a conducive situation by explicating a challenging problem. The teacher could use Student Worksheet, then the students worked in group; thus, motivation arose in the students to solve these problems (Bénéteau et al., 2017; Bressette, 2008; Douglas & Chiu, 2013; Kussmaul, 2012, 2014; Kussmaul et al., 2016, 2017).

The POGIL was actually designed to improve the context understanding from the learning material POGIL (DeMatteo, 2019; Garoutte, 2008; Hein, 2012; Walker & Warfa, 2017; Williamson et al., 2013), develop the interest and skill to follow the learning processes (Abdul-Kahar et al., 2016; Bailey, Minderhout, & Loertscher, 2012; Devitri et al., 2019;

Yuliastini et al., 2018), improve the thinking abilities (Andriani et al., 2019; Bressette, 2008; DeMatteo, 2019; Douglas & Chiu, 2013; Hein, 2012; Irwanto et al., 2018) in solving the problems (Bénéteau et al., 2017; Kim, 2018; Kussmaul & Wenzel, 2012; Rumain & Geliebter, 2020; Vincent-Ruz et al., 2020; Williamson et al., 2013), especially for the aspect of critical thinking (Irwanto et al., 2018; Kussmaul et al., 2016, 2017; Moore et al., 2015; Straumanis & Simons, 2008; Vincent-Ruz et al., 2020). The use of realia media in POGIL learning would further encourage the students to learn during the learning process (Irman, 2020; Y. D. Lestari, 2019; Ramdani, 2017). Furthermore, this media also could give direct information from the observed objects and the students could get an experience that was memorable and easy for students to remember (Budiasih et al., 2016; Y. D. Lestari, 2019; Ramdani, 2017; Setyaningsih et al., 2019; Sugiharti, 2018). In a learning that implemented the POGIL model assisted by realia media, the students were more active since the students were asked to notice and practice directly about the various forces; then, the students were asked to define the definition of force.

The POGIL was a learning model that referred to the theory of constructivism. The POGIL had various objectives, i.e. (1) to develop the mastery of concepts/contents, (2) to develop the processing skills such as problem-solving, critical thinking and analysis. The POGIL model activities were organized in three stages, namely exploration, concept discovery and application (Cole & Bauer, 2008; Roller & Zori, 2017; Schroeder & Greenbowe, 2008; Yuliani et al., 2017).

In the exploring stage, the students were guided and motivated to know all their initial knowledge related to the material discussed in the learning process. Then, in the learning process, the teacher used realia media to explain the material to be learned. With the realia media, the students would better understand the concepts learned. According to Budiasih et al (2016) and Wijayanti (2016), the realia media illustrated a learning concretely so that more stored longer in the students' memory.

The next stage was that the students were faced up with a problem given by the teacher. The students tried to answer the problem based on the initial knowledge that they had. Each problem could be arranged in a question. Based on Kim (2018), the question would encourage the students to explore the answer independently. Then, according to Straumanis and Simons (2008) and Vincent-Ruz et al (2020) who postulated that the students discussed in group that had been divided randomly.

Before conducting a simple experiment, the students tried to discover the information with their groups by discussing and reading the textbooks related to the material being studied. The learning activities at this stage provided challenges for students to actively learn and think critically. This finding was in line with Sulasmi (2018) that in the exploration stage, the students were asked to generate the whole initial knowledge regarding to the material that would be discussed.

At the concept discovery stage, the students (in groups) conducted a simple experiment. Then, they discussed and worked together to solve the problem. The teacher would motivate the students who tried to find out the concepts from the material being studied. In this phase, the students were also guided to make conclusions and then reported the findings in experiments in front of the class. Vincent-Ruz et al (2020) asserted that these activities were very good to train the students' abilities in communicating.

Group activities would make the students for being more active individually and even in group in order to solve the problems (Bailey et al., 2012; Bunce et al., 2008; Kussmaul et al., 2016; Tawil & Liliasari, 2013). The existence of collaboration activity could construct their knowledge and abilities to work in team and then it could train the students' critical thinking (Kim, 2018; Williamson et al., 2013). Thus, the experiment conducted by the students provided a meaningful learning experience, and the concept of science could be well received, and stored longer in the students' memories. In its development, if this continued, it would develop the aspects of scientific literacy and students' critical thinking (Devitri et al., 2019; Schroeder & Greenbowe, 2008; Walker & Warfa, 2017).

At the application stage, the students applied the concepts they had found by answering/completing the questions given by the teacher which aimed at testing and at the same time improving the students' understanding of the material being studied. This was in line with the statement of Umam (2016) who proposed that the concept implementation encouraged deeper understanding of students. Different from the case in the learning using expository method, it was only concerned on the teacher (teacher centered). As seen in the learning processes, the teacher dominated more than the students. The submission of material still used conventional methods, discussions, and assignments. This caused the students tended to be active in the learning processes and made the students felt bored quickly.

Conclusion

Departing from the research results and discussion above, it can be concluded that there is a significant difference between scientific literacy and students' critical thinking taught by the POGIL learning that assisted by realia media to the students who use expository learning. Due to the existence of a significant difference, it means that POGIL learning assisted by realia media has an effect on the students' scientific literacy and critical thinking.

Suggestions

It is expected that the next researches can be carried out in state schools in various regions, various cultures, in the private schools, and also various other science learning materials. Further researches can be conducted on the 5th and 6th grades. For education practitioners, it is suggested that in learning they should apply appropriate learning models and media in accordance with the characteristics of the material, students' abilities, and build good communication and interaction so that the whole learning processes can be maximally accepted by the students.

Limitations

This research is centralized on the 4th grade students and it is only for the energy material. Therefore, only one state primary school in the provincial capital is chosen to do this research.

Acknowledgement

References

Abdul-Kahar, R., Esa, F., Tay, K. G., Hashim, R., Laham, M. N., & Wong, B. Y. L. (2016). Finite element analysis (FEA) in electronics devices and photonics through process oriented guided inquiry learning (POGIL). *Journal of Telecommunication, Electronic and Computer Engineering*, *8*(6), 93–97.

Afifah, R. N. (2019). Realia media to improve students' result learning. *Jurnal Pendidikan Guru Sekolah Dasar/ Journal of Elementary School Teacher Education*, *9*(1), 891–899.

Ajar, S. A. (2017). *Masalah kemiskinan di Nusa Tenggra Timur (NTT)* [The problem of poverty in East Nusa Tenggara]. Universitas Islam Makassar.

Amin, A. M., Corebima, A. D., Zubaidah, S., & Mahanal, S. (2020). The correlation between metacognitive skills and critical thinking skills at the implementation of four different learning strategies in animal physiology lectures. *European Journal of Educational Research*, *9*(1), 143–163. https://doi.org/10.12973/eu-jer.9.1.143

Andriani, S., Nurlaelah, E., & Yulianti, K. (2019). The effect of process oriented guided inquiry learning (POGIL) model toward students' logical thinking ability in mathematics. *Journal of Physics: Conference Series*, *1157*(4), 1–5. https://doi.org/10.1088/1742-6596/1157/4/042108

Artika, W., & Saputri, M. (2018). A self-evaluation technique in improving teacher's professional development: The use of "realia" media and "wait time" strategies. *Journal of Physics: Conference Series*, *1088*, 1–6. https://doi.org/10.1088/1742-6596/1088/1/012022

Avvisati, F., Echazarra, A., Givord, P., & Schwabe, M. (2018). *Country note: Programme for International Student Assessment (PISA) Result from PISA 2018 (Indonesia).* OECD. https://www.oecd.org/pisa/publications/PISA2018_CN_IDN.pdf

Bailey, C. P., Minderhout, V., & Loertscher, J. (2012). Learning transferable skills in large lecture halls: Implementing a POGIL approach in biochemistry. *Biochemistry and Molecular Biology Education*, *40*(1), 1–7. https://doi.org/10.1002/bmb.20556

Bénéteau, C., Guadarrama, Z., Guerra, J. E., Lenz, L., Lewis, J. E., & Straumanis, A. (2017). POGIL in the calculus classroom. *Primus: Problems, Resources, and Issues in Mathematics Undergraduate Studies*, *27*(6), 579–597. https://doi.org/10.1080/10511970.2016.1233159

Braund, M., & Reiss, M. J. (2019). The 'Great Divide': How the arts contribute to science and science education. *Canadian Journal of Science, Mathematics and Technology Education*, *19*(3), 219–236. https://doi.org/10.1007/s42330-019-00057-7

Bressette, A. R. (2008). Advice from a sage who left the stage: How to have a successful POGIL journey. In R. S. Moog & J. N. Spencer (Eds.), *ACS Symposium Series* (Vol. 994, pp. 40–47). ACS.

Budiasih, K., Garminah, N. N., & Rati, N. W. (2016). Penerapan model pembelajaran kooperatif tipe NHT berbantuan media realia untuk meningkatkan hasil belajar IPA [The application of NHT type cooperative learning models is assisted by realia media to improve science learning outcomes]. *e-Journal Elementary Teacher Education of Ganesha Education University/ E-Journal PGSD Universitas Pendidikan Ganesha*, *4*(1), 1–10. https://doi.org/10.23887/jjpgsd.v4i1.7354

Bunce, D. M., Havanki, K., & Vandenplas, J. R. (2008). A theory-based evaluation of POGIL workshops: Providing a clearer picture of POGIL adoption. In R. S. Moog & J. N. Spencer (Eds.), *ACS Symposium Series* (Vol. 994, pp. 100–113). ACS.

Calado, F. M. (2013). A reflection on distorted views of science and technology in science textbooks as obstacles to the improvement of students' scientific literacy. *European Journal of Educational Research*, *2*(3), 51–68. https://doi.org/10.12973/eu-jer.2.2.51

Cejka, E., Rogers, C., & Portsmore, M. (2006). Kindergarten robotics: Using robotics to motivate math, science, and engineering literacy in elementary school. *International Journal of Engineering Education*, *22*(4), 711–722.

Cervetti, G. N., Barber, J., Dorph, R., Pearson, P. D., & Goldschmidt, P. G. (2012). The impact of an integrated approach to science and literacy in elementary school classrooms. *Journal of Research in Science Teaching*, *49*(5), 631–658. https://doi.org/10.1002/tea.21015

Chase, A., Pakhira, D., & Stains, M. (2013). Implementing process-oriented, guided-inquiry learning for the first time: Adaptations and short-term impacts on students' attitude and performance. *Journal of Chemical Education*, *90*(4), 409–416. https://doi.org/10.1021/ed300181t

Cole, R. S., & Bauer, C. F. (2008). Assessing POGIL implementations. In R. S. Moog & J. N. Spencer (Eds.), *ACS Symposium Series* (Vol. 994, pp. 213–225). ACS.

Curran, F. C., & Kitchin, J. (2019). Early elementary science instruction: Does more time on science or science topics/skills predict science achievement in the early grades? *AERA Open*, *5*(3), 1–18. https://doi.org/10.1177/2332858419861081

Darling-Hammond, L., Flook, L., Cook-Harvey, C., Barron, B., & Osher, D. (2020). Implications for educational practice of the science of learning and development. *Applied Developmental Science*, *24*(2), 97–140. https://doi.org/10.1080/10888691.2018.1537791

De Gale, S., & Boisselle, L. N. (2015). The effect of POGIL on academic performance and academic confidence. *Science Education International*, *26*(1), 56–79.

DeMatteo, M. P. (2019). Combining POGIL and a flipped classroom methodology in organic chemistry. In J. B. Houseknecht, A. Leontyev, V. M. Maloney, & C. O. Welder (Eds.), *ACS Symposium Series* (Vol. 1336, pp. 217–240). ACS.

Devitri, N., Syafriani, & Djamas, D. (2019). Validity of physics module nuanced model of process oriented guided inquiry learning (POGIL) to improve scientific literacy at 10th grade senior high school. *Journal of Physics: Conference Series*, *1185*(1), 1–7. https://doi.org/10.1088/1742-6596/1185/1/012060

Douglas, E. P., & Chiu, C. C. (2013). Implementation of Process Oriented Guided Inquiry Learning (POGIL) in engineering. *Advances in Engineering Education*, *3*(3), 1–16.

Eberlein, T., Kampmeier, J., Minderhout, V., Moog, R. S., Platt, T., Varma-Nelson, P., & White, H. B. (2008). Pedagogies of engagement in science: A comparison of PBL, POGIL, and PLTL. *Biochemistry and Molecular Biology Education*, *36*(4), 262–273. https://doi.org/10.1002/bmb.20204

Elfrida, Y., Siregar, Y., Rachmadtullah, R., & Pohan, N. (2019). The impacts of science, technology, engineering, and mathematics (STEM) on critical thinking in elementary school. *Journal of Physics: Conference Series*, *1175*(012156), 1–5. https://doi.org/10.1088/1742-6596/1175/1/012156

Facione, P. A. (2011). *Critical thinking: What it is and why it counts*. Measured Reasons LLC & Insight Assessment. http:// shorturl.at/rvC15

Faisal, & Martin, S. N. (2019). Science education in Indonesia: Past, present, and future. *Asia-Pacific Science Education*, *5*(1), 1–29. https://doi.org/10.1186/s41029-019-0032-0

Ferraz, V., & Neves, A. (2017). Childhood and schooling: Entrance of children in elementary school. *Education & Reality/ Educacao & Realidade*, *42*(1), 345–369. https://doi.org/10.1590/2175-623655336

Fitzgerald, A., & Smith, K. (2016). Science that matters: Exploring science learning and teaching in primary schools. *Australian Journal of Teacher Education*, *41*(4), 64–78. https://doi.org/10.14221/ajte.2016v41n4.4

Florea, N. M., & Hurjui, E. (2015). Critical thinking in elementary school children. *Procedia - Social and Behavioral Sciences*, *180*(November 2014), 565–572. https://doi.org/10.1016/j.sbspro.2015.02.161

Garoutte, M. P. (2008). POGIL in the general, organic, and biological chemistry course. In R. S. Moog & J. N. Spencer (Eds.), *ACS Symposium Series* (Vol. 994, pp. 122–132). ACS.

Habibah, U., & Wardhani, D. A. P. (2019). Pengaruh pengunaan media realia terhadap hasil belajar siswa pada

pembelajaran tematik kelas 1 [The effect of realia media on student learning outcomes in thematic learning class 1]. *Elementa: Journal of Primary School Teacher Education/ Elementa: Jurnal Pendidikan Guru Sekolah Dasar*, *1*(2), 158–167. https://doi.org/10.33654/pgsd.v1i2.798

Hadi, A. S. A. (2018). Effectiveness of using realia in teaching English vocabulary for ESL learners. *International Journal of Engineering Science Invention*, *7*(10), 65–72.

Hand, B., Fostvedt, L., Shelley, M. C., Therrien, W., & Laugerman, M. (2018). Improving critical thinking growth for disadvantaged groups within elementary school science : A randomized controlled trial using the Science Writing Heuristic approach. *Science Education*, *28*, 1–18. https://doi.org/10.1002/sce.21341

Harmawan, V., Pangesti, M. K., & Rokhyati, U. (2019). Students' speaking ability through realia in JHS: A literature review. *International Journal of Scientific and Technology Research*, *8*(10), 3644–3648.

Hasan, R., Lukitasari, M., Utami, S., & Anizar, A. (2019). The activeness, critical, and creative thinking skills of students in the Lesson Study-based inquiry and cooperative learning. *Indonesian Journal of Biology Education/ Jurnal Pendidikan Biologi Indonesia*, *5*(1), 77–84. https://doi.org/10.22219/jpbi.v5i1.7328

Hayati, N., & Berlianti, N. A. (2020). Critical thinking skills of natural science undergraduate students on biology subject: Gender perspective. *Indonesian Journal of Biology Education/ Jurnal Pendidikan Biologi Indonesia)*, *6*(1), 83–90. https://doi.org/10.22219/jpbi.v6i1.11150

Hein, S. M. (2012). Positive impacts using POGIL in organic chemistry. *Journal of Chemical Education*, *89*(7), 860–864. https://doi.org/10.1021/ed100217v

Hu, H. H., & Kussmaul, C. L. (2012). Promoting student-centered learning with POGIL. In L. S. King, D. R. Musicant, T. Camp, & P. Tymann (Eds.), *Proceedings of the 43rd ACM Technical Symposium on Computer Science Education* (pp. 579–580). ACM.

Hu, H. H., & Shepherd, T. D. (2014). Teaching CS 1 with POGIL activities and roles. In J. D. Dougherty, K. Nagel, A. Decker, & K. Eiselt (Eds.), *Proceedings of the 45th ACM Technical Symposium on Computer Science Education* (pp. 127–132). ACM.

Hurd, P. D. (1998). Scientific literacy: New minds for a changing world. *Science Education*, *82*(3), 407–416. https://doi.org/10.1002/(sici)1098-237x(199806)82:3<407::aid-sce6>3.0.co;2-g

Husamah, H., Fatmawati, D., & Setyawan, D. (2018). OIDDE learning model: Improving higher order thinking skills of biology teacher candidates. *International Journal of Instruction*, *11*(2), 249–264. https://doi.org/10.12973/iji.2018.11217a

Hussein, M. H., & Ow, S. H. (2019). A digital game-based learning method to improve students' critical thinking skills in elementary science. *IEEE Access*, *7*, 96309–96318. https://doi.org/10.1109/ACCESS.2019.2929089

Irawan, D. (2017). Teaching vocabulary by using realia (Real-Object) media. *English Community Journal*, *1*(1), 41–45. https://doi.org/10.32502/ecj.v1i1.650

Irman, R. (2020). Penggunaan media realia dalam meningkatkan motivasi belajar IPA pada siswa kelas IV SD Negeri Kassi Kota Makassar [The use of realia media in increasing motivation to study science in class IV SD Kassi Makassar city]. *Journal of Basic Education Studies/Jurnal Kajian Pendidikan Dasar*, *5*(1), 17–27. https://doi.org/10.26618/jkpd.v5i1.3060

Irwanto, Saputro, A. D., Rohaeti, E., & Prodjosantoso, A. K. (2018). Promoting critical thinking and problem solving skills of preservice elementary teachers through process-oriented guided-inquiry learning (POGIL). *International Journal of Instruction*, *11*(4), 777–794. https://doi.org/10.12973/iji.2018.11449a

Ismiyanti, F. (2015). Efektifitas media realia untuk meningkatkan pemahaman mengenal warna bagi anak tunagrahita sedang [The effectiveness of realia media to improve understanding of colors for children with intellectual disabilities]. *Special Education Scientific Journal/ Jurnal Ilmiah Pendidikan Khusus*, *4*(1), 197–209.

Jacob, B. A., & Rockoff, J. E. (2011). Organizing schools to improve student achievement: Start times, grade configurations, and teacher assignments. *Education Digest: Essential Readings Condensed for Quick Review*, *77*(8), 28-34.

Johnson, C. D. (2012). Meeting the ethical challenges of leadership: Casting light or shadow (4th ed.) by Craig E. Johnson. *Organization Management Journal,* 9(3), 202-205. https://doi.org/10.1080/15416518.2012.708856

Joseph, T. D. (2012). Literacy, information and communication technology as tools for empowerment of inmates. *European Journal of Educational Research*, *1*(2), 117–126. https://doi.org/10.12973/eu-jer.1.2.117

Kettler, T. (2014). Critical thinking skills among elementary school students: Comparing identified gifted and general education student performance. *Gifted Child Quarterly*, *58*(2), 127–136.

https://doi.org/10.1177/0016986214522508

Kim, S. S. H. (2018). m-POGIL (modified-process oriented guided inquiry learning) based plastics laboratory. In A. Genau & J. Callahan (Eds.), *ASEE Annual Conference and Exposition, Conference Proceedings* (pp. 1–13). ASEE.

Knain, E. (2015). *Scientific literacy for participation: A systemic functional approach to analysis of school science discourses*. Sense Publishers.

Kussmaul, C. L. (2012). Process Oriented Guided Inquiry Learning (POGIL) in computer science & software engineering. In C. L. Kussmaul (Ed.), *ASEE Annual Conference and Exposition, Conference Proceedings* (pp. 373–378). ASEE.

Kussmaul, C. L. (2014). Guiding students to discover concepts and develop process skills with POGIL. In B. Rutherfoord, L. Li, S. V. de Ven, A. Settle, & T. Steinbach (Eds.), *Proceedings of the 15th Annual Conference on Information Technology Education* (pp. 159–160). ACM.

Kussmaul, C. L., Hu, H. H., & Pirmann, T. (2016). Special session: Helping students to develop communication, teamwork, and other process skills with POGIL. In C. Alphonce, J. Tims, M. Caspersen, & S. Edwards (Eds.), *Proceedings of the 47th ACM Technical Symposium on Computing Science Education* (pp. 683–684). ACM.

Kussmaul, C. L., Mayfield, C., & Hu, H. H. (2017). Process oriented guided inquiry learning in computer science: The CS-POGIL & IntroCS-POGIL projects. In C. J. Kussmaul (Ed.), *ASEE Annual Conference and Exposition, Conference Proceedings* (Vol. 2017-June, pp. 1–7). ASEE.

Kussmaul, C. L., & Wenzel, E. (2012). Analysis of active learning activities transitions and patterns in Process Oriented Guided Inquiry Learning (POGIL). In S. Murthy & D. Sampson (Eds.), *Proceedings - 2012 IEEE 4th International Conference on Technology for Education* (pp. 7–12). IEEE.

Labov, J. B. (2006). National and state standards in science and their potential influence on undergraduate science education. *CBE - Life Sciences Education*, *5*, 204–209. https://doi.org/10.1187/cbe.06–05–0162

Lalian, O. N., Siregar, E., & Winarsih, M. (2019). The effects of using realia media on increasing science learning outcomes of elementary school students: A meta-analysis. In A. Boukerche (Ed.), *ACM International Conference Proceeding Series*: *Vol. Part F1483* (pp. 1–4). ACM.

Laursen, S., Liston, C., Thiry, H., & Graf, J. (2007). What good is a scientist in the classroom? Participant outcomes and program design features for a short- duration science outreach intervention in K–12 classrooms. *CBE - Life Sciences Education*, *6*, 49–64. https://doi.org/10.1187/cbe.06

Lee, O., Deaktor, R. A., Hart, J. E., Cuevas, P., & Enders, C. (2005). An instructional intervention's impact on the science and literacy achievement of culturally and linguistically diverse elementary students. *Journal of Research in Science Teaching*, *42*(8), 857–887. https://doi.org/10.1002/tea.20071

Lestari, N., & Mustika, E. (2014). Pengaruh penggunaan media realia terhadap keaktifan belajar siswa pada mata pelajaran ilmu pengetahuan alam di Sekolah Dasar Negeri Setia Darma 03 Tambun Selatan [The effect of the use of realia media on student learning activeness in natural science]. *Pedagogik/Pedagogic*, *2*(2), 1–8.

Lestari, Y. D. (2019). Penggunaan media realia terhadap hasil belajar siswa kelas IV SDN 1 Sidokaton [The use of realia media on student learning outcomes in class IV SDN 1 Sidokaton]. *Educational Scientific Journal/Jurnal Ilmiah Kependidikan, 12*(1), 101–108.

Libby, R. D. (2008). Phasing into POGIL. In R. Moog, D. Bunce, & J. Lewis (Eds.), *ACS Symposium Series* (Vol. 994, pp. 49–59). ACS.

Lotlikar, P. C., & Wagh, R. (2017). Using POGIL to teach and learn design patterns - A constructionist based incremental, collaborative approach. In V. Kumar, S. Murthy, & K. Kinshuk (Eds.), *Proceedings - IEEE 8th International Conference on Technology for Education, T4E 2016* (pp. 46–49). IEEE.

Maramis, A. A., Mege, R. A., Paus, J. R., & Mantiri, J. (2019). Effectiveness of realia media: A case study in SMP Negeri 1 Likupang Barat as a partner in KKN-PPM Program. *Journal of Physics: Conference Series*, *1387*(1), 1–4. https://doi.org/10.1088/1742-6596/1387/1/012070

Maryuningsih, Y., Hidayat, T., Riandi, R., & Rustaman, N. Y. (2020). The critical thinking skills of biology teacher candidates toward the ethical issues. *Indonesian Journal of Biology Education/ Jurnal Pendidikan Biologi Indonesia*, *6*(1), 65–74. https://doi.org/10.22219/jpbi.v6i1.10779

Meldawati, M. (2017). *Building students' scientific literacy through contextual learning in the physics classroom*. University of Tampere.

Mitchell, E., & Hiatt, D. (2010). Using POGIL techniques in an information literacy curriculum. *Journal of Academic Librarianship*, *36*(6), 539–542. https://doi.org/10.1016/j.acalib.2010.08.010

Moog, R. S., Creegan, F., Hanson, D., Spencer, J., & Straumanis, A. (2006). Process-Oriented Guided Inquiry Learning: POGIL and the POGIL project. *Metropolitan Universities*, *17*(4), 41–52.

Moog, R. S., & Spencer, J. N. (2008). POGIL: An overview. In R. Moog, D. Bunce, & J. Lewis (Eds.), *ACS Symposium Series* (pp. 1–13). ACS.

Moon, J. (2007). Critical thinking: An exploration of theory and practice. In *Critical Thinking: An Exploration of Theory and Practice*. Routledge.

Moore, C., Black, J., Glackin, B., Ruppel, M., & Watson, E. (2015). Integrating information literacy, the POGIL method, and iPads into a foundational studies program. *Journal of Academic Librarianship*, *41*(2), 155–169. https://doi.org/10.1016/j.acalib.2014.12.006

Muhammad, M., & Purwanto, J. (2020). The effect of Process Oriented Guided Inquiry Learning (POGIL) on mathematical problem solving abilities. *Journal of Physics: Conference Series*, *1469*(1), 1–6. https://doi.org/10.1088/1742-6596/1469/1/012171

Murnane, R., Sawhill, I., & Snow, C. (2012). Literacy challenges for the twenty-first century: Introducing the issue. *Future of Children*, *22*(2), 3–15. https://doi.org/10.1353/foc.2012.0013

Muslikah, M. (2017). Out class learning dengan media realia untuk meningkatkan hasil belajar materi plantae siswa kelas X IPA SMA Negeri 2 Demak [Out class learning with realia media to improve learning outcomes of plantae material in class X science students]. *Teacher Professional Journal / Jurnal Profesi Keguruan*, *3*(2), 170–174.

Natalina, M., Mahadi, I., & Suzane, A. C. (2013). Penerapan model pembelajaran inkuiri terbimbing (guided inquiry) untuk meningkatkan sikap ilmiah dan hasil belajar biologi [The application of guided inquiry learning models to improve scientific attitudes and learning outcomes in biology]. In S. Dwi, H. Apkuanbo, & S. Saidi (Eds.), *Proceeding od SEMIRATA* (pp. 83–92). Lampung University.

Permana, T. I., Hindun, I., Rofi'ah, N. L., & Azizah, A. S. N. (2019). Critical thinking skills: The academic ability, mastering concepts and analytical skill of undergraduate students. *Indonesian Journal of Biology Education/ Jurnal Pendidikan Biologi Indonesia*, *5*(1), 1–8. https://doi.org/10.22219/jpbi.v5i1.7626

Prasasti, P. A. T., & Listiani, I. (2019). Guided experiments book based on SETS (Science, Environment, Technology, and Society) to empower science literacy for elementary school students. *Journal of Physics: Conference Series*, *1318*(1), 1–7. https://doi.org/10.1088/1742-6596/1318/1/012018

Puspaardini, P., Ibrahim, N., Zubaidi, M., & Syahputra, H. (2019). Media realia dalam mengenalkan kosakata anak kelompok A di TK Kembang Teratai Kelurahan Lekobalo Kecamatan Kota Barat Kota Gorontalo [Realia media in introducing the vocabulary of group A children in the Kembang Teratai Kindergarten]. *JPP PAUD FKIP Untirta*, *6*(1), 63–80. https://doi.org/10.30870/jpppaud.v6i1.7373

Rahayu, S. (2017). Promoting the 21 st century scientific literacy skills through innovative chemistry instruction. In R. Riyanto, K. Merdekawati, I. Fatimah, A. Allwar, & N. Fitri (Eds.), *AIP Conference Proceedings* (Vol. 1911, pp. 1–8). AIP Publishing.

Ramdani, Z. (2017). Peningkatan kecerdasan naturalis melalui penggunaan media realia [Increased naturalist intelligence through the use of realia media]. *Journal Golden Age Hamzanwadi University*, *1*(1), 16–32. https://doi.org/10.33061/ad.v3i1.2069

Reffiane, F., Iswari, R. S., & Marwoto, P. (2019). The effectiveness of Lectora Inspire media assisted guided inquiry method on the students' critical thinking skill in the science nature: A case study at gugus Diponegoro elementary schools Semarang. *Journal of Physics: Conference Series*, *1170*(012078), 1–4. https://doi.org/10.1088/1742-6596/1170/1/012078

Ricketts, J. C. (2003). *The efficacy of leadership development, critical thinking dispositions, and student academic performance on the critical thinking skills of selected youth leaders*. The Graduate School of the University of Florida.

Rochman, C., Nasudin, D., & Rokayah, R. (2019). Science literacy on science technology engineering and math (STEM) learning in elementary schools. *Journal of Physics: Conference Series*, *1318*(1), 1–8. https://doi.org/10.1088/1742-6596/1318/1/012050

Rokayah, R., & Rochman, C. (2019). Challenges in Science Technology Engineering and Math (STEM) learning in elementary schools based on literacy of social science. *Journal of Physics: Conference Series*, *1318*(1), 1–7. https://doi.org/10.1088/1742-6596/1318/1/012049

Roller, M. C., & Zori, S. (2017). The impact of instituting Process-Oriented Guided-Inquiry Learning (POGIL) in a fundamental nursing course. *Nurse Education Today*, *50*, 72–76. https://doi.org/10.1016/j.nedt.2016.12.003

Rumain, B., & Geliebter, A. (2020). A Process-Oriented Guided-Inquiry Learning (POGIL)-based curriculum for the

experimental psychology laboratory. *Psychology Learning and Teaching*, *19*(2), 194–206. https://doi.org/10.1177/1475725720905973

Rustam, R., Ramdani, A., & Sedijani, P. (2017). The effect of Process Oriented Guided Inquiry Learning (POGIL) learning model on the understanding of Science concepts, science process skills and critical thinking ability of State Junior High School 3 students in Pringgabaya, East Lombok. *Jurnal Penelitian Pendidikan IPA/Journal of Science Education Research*, *3*(2), 33–41. https://doi.org/10.29303/jppipa.v3i2.90

Saputro, A. D., Atun, S., Wilujeng, I., Ariyanto, A., & Arifin, S. (2020). Enhancing pre-service elementary teachers' self-efficacy and critical thinking using problem-based learning. *European Journal of Educational Research*, *9*(2), 765–773. https://doi.org/10.12973/eu-jer.9.2.765

Satria, E., & Sopandi, W. (2019). Applying RADEC model in science learning to promoting students' critical thinking in elementary school. *Journal of Physics: Conference Series*, *1321*(032102), 1–8. https://doi.org/10.1088/1742-6596/1321/3/032102

Schroeder, J. D., & Greenbowe, T. J. (2008). Implementing POGIL in the lecture and the Science Writing Heuristic in the laboratory - Student perceptions and performance in undergraduate organic chemistry. *Chemistry Education Research and Practice*, *9*(2), 149–156. https://doi.org/10.1039/b806231p

Sen, S., Yilmaz, A., & Geban, O. (2016). The effect of Process Oriented Guided Inquiry Learning (POGIL) on 11th Graders' conceptual understanding of electrochemistry. *Asia-Pacific Forum on Science Learning and Teaching*, *17*(2), 1-8.

Setyaningsih, C. A., Rozanti, N., Andini, G., & Hidayat, T. (2019). Keefektifan penggunaan media realia terhadap hasil belajar IPA di sekolah dasar [The effectivity of realia media on Science learning outcomes in elementary schools]. Muara *Educational Journal / Jurnal Muara Pendidikan*, *4*(2), 321–331.

Storey, M. (2013). *Critical thinking*. Bellevue College.

Straumanis, A., & Simons, E. A. (2008). A multi-institutional assessment of the use of POGIL in organic chemistry. In R. S. Moog & J. N. Spencer (Eds.), *ACS Symposium Series* (Vol. 994, pp. 226–239). ACS.

Sugiharti, S. (2018). Penggunaan media realia (nyata) untuk meningkatkan aktifitas dan hasil belajar matematika kompetensi mengenal lambang bilangan pada siswa kelas I SDN 02 Kartoharjo Kota Madiun [The use of media realia to improve the activities and learning outcomes]. *Gemilang Education Journal/ Jurnal Edukasi Gemilang, 3*(1), 7–14.

Sujana, A., Rachmatin, D., & Panjaitan, R. L. (2019). Science and mathematics literacy of elementary school students related to water cycle. *Journal of Physics: Conference Series*, *1318*(1), 6–12. https://doi.org/10.1088/1742-6596/1318/1/012131

Sulasmi, N. M. T. (2018). Pengaruh model pembelajaran POGIL berbantuan media permainan TTS terhadap hasil belajar IPA siswa kelas V SD [The influence of the POGIL learning model assisted by the TTS game media on the learning outcomes of science students in grade V elementary]. *Journal for Lesson and Learning Studies*, *1*(2), 139–148. https://doi.org/10.23887/jlls.v1i2.14718

Sunarko, A., & Hafsah, N. (2018). Media realia dalam meningkatkan penguasaaan mufrodat di MTS Ma'arif Tembarak Temanggung [Realia media in increasing the mastery of mufrodat in MTS Ma'arif Tembarak Temanggung]. *Lisanan Arabiya/Journal of Arabic Education*, *2*(1), 121–140. https://doi.org/10.32699/liar.v2i01.556

Syaodih, E., Kurniawati, L., Handayani, H., Setiawan, D., Suhendra, I., & Hermita, N. (2019). Critical thinking skills of fifth grade elementary school students in Bandung city on the topic of water cycle in natural science subjects. *Journal of Physics: Conference Series*, *1351*(012073), 1–8. https://doi.org/10.1088/1742-6596/1351/1/012073

Tawil, M., & Liliasari, L. (2013). *Berpikir kompleks dan implementasinya dalam Pembelajaran IPA* [Complex thinking and implementation in Science learning]. UNM Press.

Trisnawati, D. F., & Kamsiyati, S. S. (2019). Efektivitas media realia dan blok pecahan terhadap kemampuan berhitung materi pecahan peserta didik sekolah dasar [The effectiveness of realia media and fraction blocks on the ability to count fractional materials in elementary school students]. *Journal of Basic Education/ Jurnal Pendidikan Dasar*, *7*(1), 46–50. https://doi.org/10.20961/jpd.v7i1.29316

Turiman, P., Omar, J., Daud, A. M., & Osman, K. (2012). Fostering the 21st century skills through scientific literacy and science process skills. *Procedia - Social and Behavioral Sciences*, *59*, 110–116. https://doi.org/10.1016/j.sbspro.2012.09.253

Umam, M. S., Indrawati, I., & Subiki, S. (2016). Pengaruh model Process Oriented Guided Inquiry Learning (POGIL) terhadap hasil belajar dan retensi hasil belajar siswa pada pembelajaran fisika SMA/MA di Kabupaten Jember [Effect of POGIL models on learning outcomes and retention]. *Journal of Physics Learning/ Jurnal Pembelajaran Fisika*, *5*(3), 205–210.

Vieira, R. M., & Tenreiro-Vieira, C. (2016). Fostering scientific literacy and critical thinking in elementary science education. *International Journal of Science and Mathematics Education*, *14*(4), 659–680. https://doi.org/10.1007/s10763-014-9605-2

Vincent-Ruz, P., Meyer, T., Roe, S. G., & Schunn, C. D. (2020). Short-term and long-term effects of POGIL in a large-enrollment general chemistry course. *Journal of Chemical Education*, *97*(5), 1228–1238. https://doi.org/10.1021/acs.jchemed.9b01052

Walker, L., & Warfa, A. R. M. (2017). Process Oriented Guided Inquiry Learning (POGIL®) marginally effects student achievement measures but substantially increases the odds of passing a course. *PLoS ONE*, *12*(10), 1–17. https://doi.org/10.1371/journal.pone.0186203

Wijayanti, D. N. (2016). Pembelajaran efektif bahasa inggris melalui lagu anak- anak untuk siswa madrasah ibtidaiyah (MI) [Effective learning of English through children's songs for madrasah ibtidaiyah (MI) students]. *Elementary*, *4*(1), 124–148. https://doi.org/10.21043/elementary.v4i1.1931

Williamson, N. M., Metha, G. F., Willison, J., & Pyke, S. M. (2013). Development of POGIL-style classroom activities for an introductory chemistry course. *International Journal of Innovation in Science and Mathematics Education*, *21*(5), 27–41.

Winarni, E. W., Hambali, D., & Purwandari, E. P. (2020). Analysis of language and scientific literacy skills for 4th grade elementary school students through discovery learning and ICT media. *International Journal of Instruction*, *13*(2), 213–222. https://doi.org/10.29333/iji.2020.13215a

Yadav, A., Kussmaul, C. L., Mayfield, C., & Hu, H. H. (2019). POGIL in computer science. In E. K. Hawthorne, M. A. Pérez-Quiñones, S. Heckman, & J. Zhang (Eds.), *Proceedings of the 50th ACMTechnical Symposium on Computer Science Education (SIGCSE '19)* (pp. 280–285). ACM.

Yayuk, E., & Husamah, H. (2020). The difficulties of prospective elementary school teachers in item problem solving for mathematics: Polya's steps. *Journal for the Education of Gifted Young Scientists*, *8*(1), 361–368. https://doi.org/10.17478/jegys.665833

Yuliani, N. P., Margunayasa, G., & Parmiti, D. P. (2017). Pengaruh model pembelajaran POGIL berbantuan peta pikiran terhadap hasil belajar IPA siswa kelas V SD [The influence of POGIL learning models assisted with mind maps on the learning outcomes of science students in grade V elementary school]. *Journal of Education Technology*, *1*(2), 117–123. https://doi.org/10.23887/jet.v1i2.11773

Yuliastini, I. B., Rahayu, S., Fajaroh, F., & Mansour, N. (2018). Effectiveness of POGIL with SSI context on vocational high school students' chemistry learning motivation. *Jurnal Pendidikan IPA Indonesia/Indonesian Science Education Journal*, *7*(1), 85–95. https://doi.org/10.15294/jpii.v7i1.9928

Zuryanty, Z., Kenedi, A. K., Chandra, R., Hamimah, H., & Fitria, Y. (2019). Problem based learning: A way to improve critical thinking ability of elementary school students on science learning. *Journal of Physics: Conference Series*, *012037*, 1–4. https://doi.org/10.1088/1742-6596/1424/1/012037