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Promoting Critical Thinking and Problem Solving Skills of Preservice Elementary Teachers through Process-Oriented Guided-Inquiry Learning (POGIL)

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In the context of 21st century learning, lecturers encounter complex challenges in optimizing learning processes and outcomes. The previous research reports that teaching method is considered as the right solution to overcome that problem. This quasi-experimental research aims to: 1) explore the difference between Critical Thinking Skills (CTS) and Problem Solving Skills (PSS) among preservice elementary teachers taught by using POGIL and traditional lecture, and 2) analyze the correlational strength between CTS and PSS. Both groups were chosen by using cluster random sampling. This research was conducted at the Universitas Muhammadiyah Ponorogo, Indonesia, involving 48 participants in the academic year 2017/2018. The CTS Essay Test was adapted from Ennis (2011) and the PSS Essay Test was adapted from Polya (1957), face validity was conducted by the experts, and obtained reliability coefficient of .88 and .89 respectively. The data were analyzed by using Mann-Whitney U-test and Spearman's rho correlation at the significance level of .05. The results show that: 1) there is a significant difference in CTS and PSS among experimental and control groups in favour of experimental group students, and 2) there is a high positive and significant correlation between both dependent variables. We recommend that lecturers need to improve students' higher-order thinking skills by using POGIL.

Keywords: critical thinking skills, POGIL, preservice elementary teachers, problem solving skills, teachers

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INTRODUCTION

In the context of 21st century teaching and learning, lecturers are required to provide more complex and dynamic learning opportunities than traditional lecturing. In this era, students are prepared to have skills and knowledge (Irwanto, Rohaeti, Widjajanti, & Suyanta, 2017), also the competence to live and work in the environment that always changes (Kuhlthau, 2010). These skills emphasize on what then students can do with the knowledge they own and how the students apply what they have learned in authentic situations (Larson & Miller, 2011). Thereby, higher education needs to equip the graduates with 21st century skills. These skills are considered as a set of skills that need to be developed by the students in facing global problems, covers creativity and innovation, communication, collaboration, critical thinking and problem solving (Irwanto, Rohaeti, & Prodjosantoso, 2018; Muhlisin, Susilo, Amin, & Rohman, 2016; Sanabria & Jesús, 2017).

One of the ultimate skills needed in 21st century learning is critical thinking. Critical thinking, one part of higher-order thinking skills, has various definitions. Ennis (1996) explains critical thinking as logical-reflective thinking emphasized on the logic, reflection, and the process of making decisions. Almost similar, Shin, Ma, Park, Ji and Kim (2015) define critical thinking as certain assessment with certain purposes generated through steps of interpretation, analysis, evaluation, and taking conclusion. In the practice, Linn (2000) states that critical thinking involves various skills such as identifying the source of information, analyzing the credibility, reflecting the information, and taking the conclusion. Although the definition of CTS is varied, however the most important factor is that students must own the skills to learn for a lifetime critically.

Critical thinking is frequently made as the basic to understand the proof, issue, and taking conclusion. Even until nowadays, the development of critical thinking skills becomes the main purpose of science learning at tertiary level. However, the empirical study in Indonesia conducted by Fuad, Zubaidah, Mahanal and Suarsini (2017), Husamah, Fatmawati and Setyawan (2018), Muhlisin et al. (2016) and Suardana, Redhana, Sudiatmika and Selamat (2018) show that students' CTS is at low level. Muhlisin et al. (2016) reports the lack of students' critical thinking can be seen from their inability in giving arguments properly, giving less logical assumption, and giving a little evaluation based on the relevant facts. They also agree that low level of students' critical thinking skills are caused by lecturer-centered learning, the lecturer at the front and the students listen; in other words, the interaction is only one way. It indicates that lecturer still has homework on how to teach science effectively and create interactive learning environments.

Besides critical thinking, problem solving skills are also important skills in teaching and learning at higher education. Problem solving is defined as formulating the new answer to create solution, in which each step is the pioneer of the next step, and the result of the previous step (Çalışkan, Selçuk, & Erol, 2010). We contend that students' skills will increase if they are involved in the problem solving and succeed in finding the solution. The problem that can improve students' problem solving skills are the problem that

enables them to analyze, synthesize, and evaluate (Ültay, 2017). Therefore, the purpose of the science learning nowadays is not only about transferring knowledge and skills, but also facilitating both of them and use the new knowledge to make decision and solve the problem (Irwanto, Rohaeti, & Prodjosantoso, 2018b; Shieh & Chang, 2014). We believe that if lecturers less apply PSS then it can become serious inhibition for the students in establishing cognitive learning process for building the coherent concept (Su, 2016).

As we know, the science learning is related to hands-on activities that require problem solving, inquiry, and critical thinking skills through inquiry-based teaching approach. It means that equipping the students with the hard-skills is not enough, they also need to be trained with soft-skills and be able to integrate both of these skills in a new situation. Nevertheless, in Indonesia, science concepts are taught by using lecturing method (Dina & Nugraheni, 2017; Sari & Purtadi, 2010). The fact is that the information accepted by the students is limited and they are less capable of generating independence and learning interest. Therefore, students are difficult in solving the problem that needs reasoning and analysis skills, difficult in explaining a concept, and tend to be passive (Irwanto, Rohaeti, Widjajanti, & Suyanta, 2017b; Rivas, 2017; Rohaeti, Suwardi, & Ikhsan, 2013). Furthermore, Jupri and Drijvers (2016) found the students experiencing difficulty in solving the problem related to words, phrases or sentences; and formulating the equation, scheme or diagram in the topic of linear equations in one variable using a mathematical perspective. In Greece, Salta and Tzougraki (2004) report that the students experience difficulty in understanding and applying the chemical concept such as atoms, molecules, mass, volume, and mole, they also have difficulty in solving chemical problem that needs mathematical skills. Consequently, it still becomes the biggest challenge for lecturer to find the suitable teaching method to develop higher-order thinking skills.

In order to improve both of these skills among preservice teachers, the effort of their performance improvement has been done. From the literature reviewed, as the solution, we found out that the acquisition of critical thinking and problem solving skills can be improved through the implementation of collaborative inquiry-based learning (Duran & Dökme, 2016; Espinosa, Monterola, & Punzalan, 2013; Kowalczyk & Leggett, 2005; Miri, David, & Uri, 2007; Styron, 2014; Wartono, Hudha, & Batlolona, 2018), in which the learning process is emphasized on developing metacognitive skills, such as building some solution, testing the solution, and evaluating the results (Schraw, Crippen, & Hartley, 2006). Through the activity that involves the students in scientific investigation, they are expected to construct their knowledge independently by connecting the new knowledge with the prior knowledge (Fay, Grove, Towns, & Bretz, 2007). Why do these skills become the compulsory competence to be owned by the students nowadays? We strongly believe that good CTS and PSS will generate the higher education graduates that are ready to compete in the global community.

Nowadays, the paradigm of teaching and learning has shifted from lecturer-centered to student-centered approach. One of the methods that can improve their science achievement is Process-Oriented Guided-Inquiry Learning (POGIL). POGIL is a collaborative-constructivist learning method that uses guided-inquiry in the cycle of exploration, finding the concept, and a very structured application during building the

content (Rege, Havaldar, & Shaikh, 2016; Trevathan, Myers, & Gray, 2014). In detail, Villagonzalo (2014) pointed that POGIL activities focus on the core concept and the scientific process because it can propel and grow deep understanding about the learning material while developing higher-order thinking skills. We prefer to choose POGIL because it is different from other inquiry-based methods, in which the guided level is directed to acquire the concept with process-oriented, more constructive and interactive, and each student has his/her own role in finding the concept (Farrell, Moog, & Spencer, 1999; Hu, Kussmaul, Knaeble, Mayfield, & Yadav, 2016; Williamson, Metha, Willison, & Pyke, 2013).

Various evidences show that POGIL has positive impact towards students' achievement. In Turkey, Şen, Yılmaz and Geban (2015) examine the effect of POGIL on 115 eleventh-graders' conceptual understanding of electrochemistry. Their findings, that method generates students' scientific conceptual acquisition and change better misconception compared to traditional teaching method. Furthermore, Brown (2010) integrates POGIL into medicinal chemistry course, at the end of the treatment, Brown found out improvement on the grade outcomes, propel students' active involvement with the material during the course, and create participative class environment. Soltis, Verlinden, Kruger, Carroll and Trumbo (2015) also report that POGIL has improved the performance and higher-order thinking skills of first-year pharmacy students in an introduction to pharmaceutical sciences course. Moreover, De Gale and Boisselle (2015) reveals that POGIL can improve students' academic confidence at organic chemistry course. Lastly, Walker and Warfa (2017) found out that students in POGIL class had higher chance to pass the course and had higher achievement than participants in the standard lectures class and POGIL decreases the failure risk in the course in the amount of thirty-eight percent.

However, the previous research shows that POGIL method is not used yet to promote CTS and PSS of preservice elementary teachers. In addition, there are very few researchers who report that findings in the field of science education (Arsal, 2017; Qing, Jing, & Yan, 2010). Although these skills have been developed at higher education for some last decades, nevertheless the students' performances need to be improved the satisfying level continuously. We contend that it is very important for the students to own both of these skills in learning science, one of them can be achieved through different teaching method. For this reason, this research aims to examine if there is a significant difference between CTS and PSS scores of preservice elementary teachers taught by using POGIL method and traditional lecture. It is strongly believed that this research will benefit the lecturers about the method they can apply in the classroom, until they can optimize the learning process and outcomes. Consequently, it will enhance the quality of education at once providing positive contribution towards literature enrichment in primary education.

METHOD

Research Design

This research employed a quasi-experimental control group pretest-posttest design. Pretest-posttest design was used to compare groups in which one or more experimental

groups were exposed to treatment or intervention, then compared to one or more control groups that did not receive the treatment (Dimitrov & Rumrill, 2003). This current study consisted of one independent variable (i.e., teaching methods) and two dependent variables (i.e., critical thinking and problem solving skills). At the end of six weeks treatment, the experimental group (POGIL method) compared to control group (traditional lecture method) to determine which teaching method that has significant effect towards the performance of preservice elementary teachers. Pretest and posttest control group design was illustrated at Table 1 (Creswell, 2012).

Table 1
Nonequivalent pretest and posttest control group design.

Group	Pretest	Treatment	Posttest
Experimental	O_1	POGIL	O_2
Control	O_1	-	O_2

Participants

The participants covered 48 second-year students (18 males, 30 females) who took Teaching Science in Elementary School Course at the Department of Elementary School Education, Universitas Muhammadiyah Ponorogo, Indonesia, in the **odd** semester of the academic year 2017/2018. The experimental group consisted of 24 students (5 males, 19 females) and control group consisted of 24 students (13 males, 11 females). One of the class was randomly made as the experimental group, while another class was made as the control group by using cluster random sampling. Both groups had almost similar characteristics. The average age of the students was 19, ranged from 18 to 21 years old.

Data Collection Instruments

The instruments used in this research were Critical Thinking Essay Test (CTET) consisting of 5 items and Problem Solving Essay Test (PSET) consisting of 4 items. The instruments were constructed by the researchers, and validated by the instructional experts and senior lecturers from Universitas Muhammadiyah Ponorogo. The CTET covered 5 indicators; elementary clarification, bases for a decision, inference, advanced clarification, and supposition and integration, adapted from Ennis (2011), Mundilarto & Ismoyo (2017) and Wartono et al. (2018). While the PSET covered 4 indicators; understand the problem, devise a plan, carry out the plan, and look back, which were adapted from Polya (1957), Lee and Chen (2015) and Lee (2017). Both of the tests were validated and empirically tested, then the reliability of the instruments was examined. The Cronbach's alpha coefficient of CTET was α=.88, and PSET was α=.89. The coefficient reliability of both tests was above acceptance limit .70 (Hair, Black, Babin, & Anderson, 2010), thus both tests were considered reliable.

Procedure

Before conducting the research, the researchers asked for permission from The Head of Department of Elementary School Education, Universitas Muhammadiyah Ponorogo. The research was conducted for 4 months, started from February to May 2018. The CTS and PSS data were collected twice, as pretest and posttest. During the instruction,

students at experimental group were taught by using POGIL method, while students at the control group were taught by using traditional teaching method. Before starting the research, all instruments were applied to both groups as the pretest. Then, students follow the face-to-face course for 100 minutes per week. In this treatment, both groups were taught by the same lecturer to avoid instructor bias. Table 2 showed the syntax of POGIL method adapted from Chase, Pakhira and Stains (2013), De Gale and Boisselle (2015), Moog, Creegan, Hanson, Spencer and Straumanis (2006) and Rege et al. (2016).

Table 2
The syntax of POGIL method at the experimental group.

Phases	Activities
Exploration	The students discussed in small groups (4 students), analyzed various questions and information, proposed and tested hypothesis, explained and understood the information to develop the conceptual comprehension.
Concept Invention	The concept was not given explicitly, however students were propelled to make a conclusion or prediction. The lecturer moderated the students to report their findings and the results were interrogated by all students.
Application	The students solve the problem in the real world, covered the Analyze, Evaluate, and Create in accordance with Bloom's revised taxonomy. Then, the students were faced with higher order thinking skills questions.
Self-Evaluation	The students evaluated and reflected the learning achievement, what they had achieved and not achieved yet, then improved their performance at the next lectures.

Data Analysis

In this research, the quantitative data analysis used non-parametric statistics because the size of the sample was small (less than 30 participants) (Bernard, 2000; Green & Salkind, 2008). Descriptive statistics included mean, standard deviation, maximum and minimum scores were used to obtain the characteristics of the participants. Mann-Whitney U-test was employed to test if there is mean difference between two groups, and Spearman's rho correlation was performed to explore the correlation between dependent variables. Inferential analysis was computed at the significance level of .05 by using statistical program SPSS 17.0.

FINDINGS

At the beginning of the lecture, pretest was conducted. Students at the control group obtained average CTS score slightly higher than experimental group in terms of bases for a decision and advanced clarification skills. Although at three other skills, experimental group showed a bit more prominent result. While at the end of the lecture, experimental group dominated the posttest score in all sub-skills. There was improvement in the average pretest and posttest scores from 10.08 to 17.96 (increased 7.88) and 10.13 to 14.75 (increased 4.62) for experimental and control groups respectively. It can be seen that students at experimental group showed CTS improvement after obtaining the treatment (Table 3).

Table 3
Descriptive data of preservice elementary teachers' critical thinking skills.

Group	Descriptive Statistics	Pretest						Posttest					
		Overall CTS	Elementary Clarification	Bases for a Decision	Inference	Advanced Clarification	Supposition and Integration	Overall CTS	Elementary Clarification	Bases for a Decision	Inference	Advanced Clarification	Supposition and Integration
Experimental Group (N=24)	Mean	10.08	2.29	2.33	2.25	1.96	1.25	17.96	3.96	3.92	3.71	3.38	3.00
	Std. Deviation	1.501	.464	.482	.676	.464	.442	1.334	.204	.282	.464	.495	.590
	Minimum	8	2	2	1	1	1	16	3	3	3	3	2
	Maximum	13	3	3	3	3	2	20	4	4	4	4	4
Control Group (N=24)	Mean	10.13	2.21	2.42	2.17	2.17	1.17	14.75	3.08	3.50	3.21	2.75	2.21
	Std. Deviation	1.296	.415	.504	.565	.482	.381	1.511	.408	.511	.509	.608	.415
	Minimum	7	2	2	1	1	1	13	2	3	2	2	2
	Maximum	12	3	3	3	3	2	18	4	4	4	4	3

Different from pretest score in CTS, at the beginning of the course, students at experimental group had average PSS score slightly higher than all sub-skills, except understand the problem skill. While at the end of the course, experimental group dominated the posttest score in all sub-skills. There was improvement on pretest and posttest scores from 8.79 to 14.17 (increased 5.38) and 10.13 to 14.75 (increased 3.87) for experimental and control groups respectively. It can be seen that students in experimental group were more superior than students in control group after the implementation of POGIL method (Table 4).

Table 4
Descriptive data of preservice elementary teachers' problem solving skills.

Group	Descriptive Statistics	Pretest					Posttest				
		Overall PSS	Understand the Problem	Devise a Plan	Carry out the Plan	Look Back	Overall PSS	Understand the Problem	Devise a Plan	Carry out the Plan	Look Back
Experimental Group (N=24)	Mean	8.79	2.79	2.42	2.21	1.38	14.17	3.79	3.71	3.58	3.08
	Std. Deviation	1.414	.658	.654	.415	.495	1.007	.415	.464	.504	.408
	Minimum	6	2	1	2	1	12	3	3	3	2
	Maximum	11	4	3	3	2	16	4	4	4	4
Control Group (N=24)	Mean	8.46	2.88	2.38	1.96	1.25	12.33	3.33	3.33	3.00	2.67
	Std. Deviation	1.179	.338	.495	.550	.442	1.167	.482	.482	.590	.482
	Minimum	6	2	2	1	1	11	3	3	2	2
	Maximum	10	3	3	3	2	15	4	4	4	3

To examine whether there was a significant difference on pretest CTS score between the two groups, we adopted Mann-Whitney U-test. Overall, there was no significant difference between students taught by using POGIL method and traditional lecture approach (U= 269.000; p=688). More details (see Table 5), the results of statistical analysis also showed that there was no significant difference on pretest score between both groups in all sub-skills (p>.05).

Table 5
The difference of pretest problem solving skills score between experimental and control groups.

Sub-Skills	Group	N	Mean Rank	Sum of Ranks	Mann-Whitney U-test	
					U	p
Elementary Clarification	POGIL	24	25.50	612.00	264.000	.509
	Traditional	24	23.50	564.00		
Bases for a Decision	POGIL	24	23.50	564.00	264.000	.555
	Traditional	24	25.50	612.00		
Inference	POGIL	24	25.50	612.00	264.000	.573
	Traditional	24	23.50	564.00		
Advanced Clarification	POGIL	24	22.27	534.50	234.500	.133
	Traditional	24	26.73	641.50		
Supposition and Integration	POGIL	24	25.50	612.00	264.000	.482
	Traditional	24	23.50	564.00		
Overall CTS	POGIL	24	23.71	569.00	269.000	.688
	Traditional	24	25.29	607.00		

The similar results, both groups showed that there was no significant difference on overall pretest PSS score between experimental and control groups (U=249.500; p=.416). Even, we did not find the existence of score difference in overall sub-skills (p>.05) (see Table 6). It means that all participants had equal skills and conceptual understanding at the beginning of the course.

Table 6
The difference in pretest problem solving skills score between experimental and control groups.

Sub-Skills	Group	N	Mean Rank	Sum of Ranks	Mann-Whitney U-test	
					U	p
Understand the Problem	POGIL	24	23.31	559.50	259.500	.460
	Traditional	24	25.69	616.50		
Devise a Plan	POGIL	24	25.38	609.00	267.000	.623
	Traditional	24	23.63	567.00		
Carry out the Plan	POGIL	24	27.08	650.00	226.000	.091
	Traditional	24	21.92	526.00		
Look Back	POGIL	24	26.00	624.00	252.000	.355
	Traditional	24	23.00	552.00		
Overall PSS	POGIL	24	26.10	626.50	249.500	.416
	Traditional	24	22.90	549.50		

At the end of the course, posttest was applied. Overall, there was a significant difference in CTS between experimental and control groups (U=37.500; p=.000). It was seen from the mean rank that difference was also observed in all sub-skills (p>.05). It reflected that students in experimental group were more dominant in acquiring CTS compared to their counterparts (Table 7).

Table 7
The difference on posttest critical thinking skill score between experimental and control groups.

Sub-Skills	Group	N	Mean Rank	Sum of Ranks	Mann-Whitney U-test	
					U	p
Elementary Clarification	POGIL	24	34.52	828.50	47.500	.000
	Traditional	24	14.48	347.50		
Bases for a Decision	POGIL	24	29.50	708.00	168.000	.002
	Traditional	24	19.50	468.00		
Inference	POGIL	24	30.15	723.50	152.500	.001
	Traditional	24	18.85	452.50		
Advanced Clarification	POGIL	24	30.50	732.00	144.000	.001
	Traditional	24	18.50	444.00		
Supposition and Integration	POGIL	24	32.42	778.00	98.000	.000
	Traditional	24	16.58	398.00		
Overall CTS	POGIL	24	34.94	838.50	37.500	.000
	Traditional	24	14.06	337.50		

The similar trend was also found in PSS acquisition. Overall, there was a significant difference on posttest score between experimental and control groups (U=76.000; p=.000). Even that significant difference was reflected at all sub-skills (p<.05). It claimed that POGIL method effectively can improve PSS of preservice elementary teachers compared to their counterparts (Table 8).

Table 8
The difference on posttest problem solving skills score between experimental and control groups.

Sub-Skills	Group	N	Mean Rank	Sum of Ranks	Mann-Whitney U-test	
					U	p
Understand the Problem	POGIL	24	30.00	720.00	156.000	.002
	Traditional	24	19.00	456.00		
Devise a Plan	POGIL	24	29.00	696.00	180.000	.010
	Traditional	24	20.00	480.00		
Carry out the Plan	POGIL	24	30.33	728.00	148.000	.001
	Traditional	24	18.67	448.00		
Look Back	POGIL	24	29.00	696.00	180.000	.003
	Traditional	24	20.00	480.00		
Overall PSS	POGIL	24	33.33	800.00	76.000	.000
	Traditional	24	15.67	376.00		

After exploring students' CTS and PSS, we predicted that there was correlation among these two skills. To analyze how close was the correlation between both of them, Spearman's rho correlation was used. The findings indicated that there was a high positive and significant correlation between critical thinking and problem solving skills (r=.619; p=.000). The reason for this may be the fact that the critical thinking and problem solving levels of the students were high. It pointed that the higher students' CTS, then their PSS will also be higher (Table 9).

Table 9
Spearman's rho correlation between dependent variables.

	Critical Thinking Skills	N	p
Problem Solving Skills	.619**	48	.000

*Note: ** p < .05*

DISCUSSION

The core of constructivism learning process is helping the students to grow critical thinking and foster their problem solving skills during the teamwork (Avsec & Kocijancic, 2014; Shieh & Chang, 2014). In this context, lecturer plays an important role in understanding students' learning needs and providing an adequate method to help them to achieve their learning purposes. In the current study, the effectiveness of POGIL method towards CTS and PSS of preservice teachers has been explained. We do not find significant difference between experimental and control groups based on the pretest score. It shows that students' initial skills were similar in both groups, until it can be concluded that they have equal initial skills. At the beginning of the instruction, both groups had CTS and PSS scores at medium level, however at the end of the application, experimental group students were taught by using POGIL method experienced posttest score improvement in all sub-skills to the higher level compared to control group that were taught by using traditional lecture approach. We see that the students taught by using traditional approach experienced difficulty in connecting the concept and applying their knowledge to problem solving situation, as reported by Orbanić, Dimec and Cencič (2016).

The first research question aims to explore the difference of CTS and PSS among preservice elementary teachers taught by using POGIL method and traditional lecture. The result of U-test towards posttest score indicated that experimental group has significant effect towards students' performance compared to control group. In this case, POGIL method is more effective in improving students' critical thinking and problem solving skills. We claim that the high score of experimental group students is related to course activities designed to teach content and engage students in analyzing data, discussing ideas, making a conclusion, and building their own knowledge through teamwork in accordance with inquiry approach principles. Students agree that teamwork is the best way to solve the problem, therefore, it is important for the students to share ideas and thoughts actively about the problems being encountered (Shieh & Chang, 2014). It is assumed that experimental group students have better achievement because they construct their skills by exploring the problem through group discussions with peers and lecturer, inventing the concept through their experiences, applying the concept through inquiry, and self-evaluation towards learning process intensively. Hence, the activities done by the students contribute positively to the development of their cognitive thinking skills.

Parallel with our findings, Apedoe, Walker and Reeves (2006) notes that inquiry-based learning is very important to develop students' critical thinking, sharpen non-routine problem solving skills, and promote scientific content knowledge at the university or college level. In Slovenia, Avsec and Kocijancic (2014) explore learning outcomes on

91 middle school students and find out that inquiry approach can improve problem solving, critical thinking, and decision-making skills. In Thailand, when Chanprasitchai and Khlaisang (2016) integrates digital technology into the course, they report that inquiry-based learning for a virtual learning community can enhance problem solving skills. Our findings are also supported by other similar studies (e.g., Duran & Dökme, 2016; Gupta, Burke, Mehta, & Greenbowe, 2015; Qing et al., 2010; Seyhan, 2015; Soltis et al., 2015). Accordingly, we believe that critical thinking and problem solving skills can be improved through the activity of developing content knowledge and process skills and forming the mental simultaneously.

The second research question aims to analyze the correlation between CTS and PSS of preservice elementary teachers taught by using POGIL method. The result of Spearman's rho correlational test towards posttest score indicates that there is a strong positive association between both skills. It shows that students' problem solving skills increase when their critical thinking skills increase. Based on the results of essay test, the students that have high CTS score, they tend to be better in acquiring PSS. It is possibly because the learning method and the questions presented at "Application" phase facilitates the students in solving the problem at once lead them to do high-level thinking in accordance with Bloom's taxonomy. As a result, that questions can optimize students' cognitive thinking skills. We predict that the type of question also influence students' performance, as reported by Chase et al. (2013). In line, Friedel, Irani, Rhoades, Fuhrman and Gallo (2008) express that the problem solving and critical thinking contribute to explain the correctness level in the solution provided by the students. Thereby, we suggest that higher order thinking questions need to be trained to generate the scientific concept through inquiry-oriented course.

According to the results of the present study, there are some contradictive findings on the literature about critical thinking and problem solving skills. As an example, Friedel et al. (2008) and Girot (2000) indicates that there is no significant correlation between critical thinking and problem solving levels. Even, Hoffman and Elwin (2004) reported that critical thinking skills and confidence in decision-making correlate negatively, it means, when the score in critical thinking increases, score in decision-making decreases. In this case, decision-making is one of the components that is very necessary in solving the problem. Nevertheless, our findings are in line with the studies by Kim and Choi (2014), Memduhoğlu and Keleş (2016) and Tümkaya, Aybek and Aldağ (2009) that confirm that there is a positive and significant correlation between both variables. Afterwards, Heidari and Shahbazi (2016) and Kanbay and Okanlı (2017) propose that problem solving positively influence students' critical thinking skills. It can be concluded that effective problem solving with complex problem that need more skills and thoughts. As we expected, Tümkaya et al. (2009) also reveals that problem solving skills are related to critical thinking, in which better critical thinking skills are attributed to bigger problem solving. They also suggest that instructional program needs to be included into the curriculum of higher education in order to support critical thinking and problem solving skills.

The key to students' academic achievement is involving them in the learning process to develop critical thinking, problem solving, collaborative, creative thinking, and metacognitive skills. Finally, we suggest to the future researchers, because there is a significant correlation between critical thinking and problem solving skills, then the course needs to prioritize these skills to enhance students' achievement. In teaching process, students must be propelled to deliver and protest opinion, identify and clarify the problem, and respond and present various solution on the problem being faced. Equally important, lecturer also must understand how to apply constructive teaching method in accordance with students' characteristics. In addition, we recommend to the lecturers to integrate digital technology to inquiry course in order to foster 21st century skills through the use of e-learning in higher education (Chanprasitchai & Khlaisang, 2016). As mentioned above, higher education institution must create climate that supports lecturers to plan, implement, and evaluate innovative and participative learning program that can improve students' learning outcomes through inquiry process.

CONCLUSION AND SUGGESTIOS

Based on the results, it can be concluded that there is a significant difference in CTS and PSS between experimental group taught by using POGIL and control group taught by using traditional lecture approach. At the end of the course, experimental group students show domination on posttest score in all sub-skills of critical thinking and problem solving skills ($p<.05$). Experimental group indicates that the improvement on both skills is higher compared to control group. Another finding shows that there is a high positive and significant correlation between critical thinking and problem solving skills ($r=.619$; $p=.000$). It means that POGIL is an effective method in improving student performance; and it can be seen from students' problem solving skills that student performance increases when their critical thinking skills increase.

Beneficial findings, all students in experimental group show a very good performance in solving the problem during the course process and various questions at the end of the course under POGIL method. According to current results, using guided-inquiry strategy enables students to engage, discover, draw conclusions, and report their findings, and then promote their critical thinking and problem solving skills (Maxwell, Lambeth, & Cox, 2015). This finding implies that inquiry learning is necessary to be made as a priority in science learning at all educational levels, especially at the tertiary level. Therefore, students need to be given more opportunities to analyze various questions, make some inferences, develop the concept, solve unstructured problems, and evaluate and reflect their findings.

These results provide an alternative to lecturers, course designers, and curriculum developers to use POGIL method in teaching process. Nevertheless, they need to consider the characteristics of this method because the type of the problems, lecturer's role, learning environment, teaching materials, and students' active participation in teamwork give impact towards students' learning outcomes. Moreover, the results of this research need to give further evidence through investigating the effect of POGIL towards the cognitive skills or other educational backgrounds by involving more

participants, longer period of time, and compared to other constructive methods. It is expected to obtain more comprehensive results.

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