

Analyzing the Relationships between Pre-Service Chemistry Teachers' Science Process Skills and Critical Thinking Skills

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ABSTRACT

This research investigated the relationships between pre-service chemistry teachers' science process skills and critical thinking skills. The sample consisted of 146 pre-service chemistry teachers (47 males, 99 females) drawn from an Indonesian public university in the first semester of 2017/2018 academic year. Through a quantitative correlational research design, convenience sampling was employed. To collect data, an Observation Checklist for Science Process Skills (OCSPS) and an Oliver-Hoyo Rubric for Critical Thinking Skills (OHRCT) were used. The results showed that pre-service chemistry teachers' science process and critical thinking skills were low. Further, it was found that there was a significant difference between mean scores of females' and males' science process skills and critical thinking skills in favor of females' ones ($p < .05$). Furthermore, it was elicited that there was a significant difference between mean scores of their science process skills and critical thinking skills in terms of grade ($p < .05$). Lastly, a high positive and linear correlation between their science process skills and critical thinking skills appeared when chemistry laboratory course was taken into consideration ($r = .793$; $p < .05$). It can be concluded that an increase in students' critical thinking skills influences their science process skills. To improve their performances through research-based educational programs, some implications were made.

Keywords: Chemistry laboratory course, critical thinking, pre-service chemistry teachers, science process skills.

INTRODUCTION

Nowadays, the laboratory has a vital role in enhancing the effectiveness of chemistry teaching and learning. More broadly, the purpose of higher education in the 21st century is to equip graduates with relevant knowledge and skills to meet the workforce. One of the skills in



the 21st century is science process skills that students need to acquire through scientific inquiry (Aktamiş, Hiğde, & Özden, 2016; Özdemir & Işık, 2015). Science process skills (SPS) actively engage students in inquiry-based activities/tasks, enable them to learn research methods, and give opportunities for them to capture experimental learning through science laboratory (Alkan, 2016; Bolat, Türk, Turna, & Altınbaş, 2014). Also, SPS stimulate their learning curiosity and develop their content knowledge. It revealed that laboratory works would not be effective without using science process skills (Ambross, Meiring & Blignaut, 2014; Durmaz & Mutlu, 2016). Consequently, in order to develop continuous learning, students need to apply scientific skills intensively (Cigrik & Ozkan, 2015). In other words, SPS are an integral part of science laboratory activities.

SPS not only act as a tool to explore their conceptions of scientific concepts but also construct scientific concepts in their cognition structures (Gultepe, 2016). SPS also allow students to test various scientific investigation methods/ways to enrich their scientific knowledge (Abungu, Okere, & Wachanga, 2014; Celep & Bacanak, 2013). Science process skills are generally classified into two types; basic and integrated process skills (Aka, Güven, & Aydoğdu, 2010; Karamustafaoğlu, 2011; Karsli & Şahin, 2009; Özgelen, 2012; Padilla, 1990). Specifically, basic process skills (i.e., observing, inferring, measuring, communicating, classifying, and predicting) and integrated process skills (controlling variables, formulating hypotheses, interpreting, and experimenting) are used to obtain chemistry knowledge and comprehend chemical concepts through scientific investigations (Tosun, 2019; Tosun & Taskesenligil, 2013).

A number of studies have been conducted to find out the correlation between science process skills and other related variables. Padilla, Okey, and Dillashaw (1983), who explored the correlation between science process skills and formal thinking abilities, found a strong relationship between these two variables. Wone and Chye (1989) expressed that science process skills were significantly related to achievement level. Furthermore, Feyzioğlu (2009), who investigated the correlation between improvement in science process skills and learning achievement, found a positive and linear correlation between science process skills and efficient laboratory use.

Additionally, it also can be understood from the review of related literature on this matter that science process skills might be influenced by gender (Beaumont-Walters & Soyibo, 2001; Ongowo, 2017; Irwanto, Rohaeti, & Prodjosantoso, 2018a; Zeidan & Jayosi, 2015) and grade (Aydinli et al., 2011; Aydoğdu & Buldur, 2013; Gürses, Çetinkaya, Doğar, & Şahin, 2015; Tek & Ruthven, 2005). More broadly, Aydoğdu, Erkol, and Erten (2014) reported that elementary school teachers' science process skills were unsatisfactory and also influenced by gender and seniority. Supportively, Erkol and Ugulu (2014) showed that pre-service biology teachers' science process skills have to be enhanced. Further, a significant gap was found when their scores were compared based on grade. Beaumont-Walters and Soyibo (2001) also found that a gap existed between grades in favor of tenth-grade students. A significant correlation between gender and grade was found by Tek and Ruthven (2005), in which grade showed strong effects on integrated process skills.

In Indonesia, one of the purposes of chemistry teaching is to enable students to apply science process skills in order to understand the concepts, issues, and phenomena. In this context, students are required to master generic skills and use scientific facts in complex situations (Brown, White, Wakeling, & Naiker, 2015). Consequently, if students are actively involved in various investigations, they become more confident, mastering science process skills and critical thinking (Deters, 2005). In other words, science process skills facilitate students to develop higher mental skills (Karsli & Şahin, 2009). However, if the science process skills are not well developed, then the concept that emerges cannot lead the students

in understanding the world around them (Seetee, Coll, Boonprakob, & Dahsah, 2016). As a result, this can certainly affect the students' ability in solving problems.

Currently, education in the 21st century should provide students with more complex learning opportunities. Students are not only taught to master the science process skills, but also the ability to become critical thinkers. This is because science process skills are associated with various aspects of cognitive skills, one of which is critical thinking skills. A good critical thinker usually develops an inquiry attitude to recognize underlying assumptions, find reasons, and evaluate evidence that refers to conclusions (Danczak, Thompson & Overton, 2017). Critical thinking is not an innate skill; thereby, the students should be trained to assess problems from various perspectives and be open-minded in developing content knowledge (Stephenson & Sadler-McKnight, 2016; Utriainen, Marttunen, Kallio, & Tynjälä, 2017). Essentially, critical thinking is an important skill needed by students at tertiary level.

In addition to science process skills, higher education purposes to effectively develop students' critical thinking skills (CTS). That is, pre-service chemistry teachers need to have the abilities of problem-solving strategies (e.g., assessing problems, and finding proper solutions), and logically consider how to apply their gains to real situations. Conceptually, critical thinking involves reasoning and active consideration rather than directly accepting any idea (Fahim & Pezeshki, 2012). Critical thinking indicators include clarity, accuracy, precision, consistency, relevance, sound evidence, good reasons, depth, breadth, and fairness (Gupta, Burke, Mehta, & Greenbowe, 2015; Oliver-Hoyo, 2003). Critical thinking skills can be developed by encouraging students to conduct experimental investigations (Kitot, Ahmad, & Seman, 2010; Miri, David, & Uri, 2007; Qing, Ni, & Hong, 2010). In brief, it is believed that all graduates have to possess critical thinking skills. College and university graduates with good critical thinking skills may challenge within a globally competitive community (Tung & Chang, 2009).

Critical thinking is the ability to apply high-level cognitive skills and attitudes to thinking that leads to logical actions (Papp et al., 2014). Supportively, critical thinking is seen as a cognitive process used in decision making, divergent thinking, problem-solving, reasoning, and investigation (Alazzi, 2008; Carvalho et al., 2015). Stephenson and Sadler-McKnight (2016) revealed that learning chemistry enables students to foster critical thinking that can be applied to other real-world situations. The knowledge and skills that students acquire through critical thinking can be applied to solve problems in new contexts (Irwanto, Saputro, Rohaeti, & Prodjosantoso, 2018; Murawski, 2014). For this reason, critical thinking needs to be possessed by students, both in the classroom and upon entering the workforce (Stupnisky, Renaud, Daniels, Haynes, & Perry, 2008). Henceforth, it is important for educators to teach and evaluate the students' level of critical thinking skills and science process skills early on.

Earlier studies have frequently been conducted to understand the effect(s) of critical thinking skills on academic learning skills. For example; Heidari and Ebrahimi (2016), who investigated the correlation between critical thinking and decision abilities, found that critical thinking significantly correlates with decision-making ability. Dowd, Thompson, Schiff, and Reynolds (2018), who investigated the relationship(s) between American undergraduate biology students' critical thinking and scientific reasoning skills, concluded that scientific reasoning in writing strongly correlated with inferring-skill, one of the critical thinking dimensions. Yenice (2012), who observed Turkish pre-service science teachers' learning styles and critical thinking, reported that several factors (e.g., gender, grade, and age) had influential roles at their learning styles and critical thinking. Meanwhile, Turan (2016) reported that pre-service teachers' critical thinking dispositions were medium and confirmed

the existence of a significant gap when students' critical thinking disposition score was linked with gender.

In another context, Akgun and Duruk (2016) found out that critical thinking dispositions of pre-service science teachers were low. Özyurt (2015) reported that the students had high-level critical thinking dispositions and problem-solving skills; a statistically significant correlation was found between critical thinking dispositions and problem-solving skills. Moreover, Ülger (2016) found a statistically significant correlation between creative thinking and critical thinking skills. The positive correlation was then linked with the utilization of non-routine problem-solving processes applied by students during their studies. Finally, Chase et al. (2017) also reported that the scientific experience of students in the laboratory and interest in chemistry increased significantly through course-based research, compared to when they were taught using traditional laboratory activities.

Research Focus

Related literature has emphasized the roles of science process skills and critical thinking skills on supporting academic achievement levels. Unfortunately, few studies in Indonesia have explored the relationship(s) between pre-service chemistry teachers' science process skills (e.g., Adnyana & Citrawathi, 2017; Hardianti & Kuswanto, 2017; Osman & Vebrianto, 2013) and critical thinking skills (e.g., Hakim, Liliyasi, Kadarohman, & Syah, 2016; Mahanal, Zubaidah, Bahri, & Dinnurriya, 2016; Muhlisin, Susilo, Amin, & Rohman, 2016; Wartono, Hudha, & Batlolona, 2018). Therefore, the current research focused on comprehensively identifying and investigating the relationship(s) between science process skills and critical thinking skills. The results would serve as a basis for improving pre-service chemistry teachers' engagement and academic performances.

The Aims of the Study

This study aims to: 1) identify SPS and CTS levels, 2) examine differences between SPS and CTS scores by gender and grade, and 3) investigate the relationship between SPS and CTS of pre-service chemistry teachers. The research questions that underlie this study are:

1. What are pre-service chemistry teachers' science process skills and their critical thinking skills levels?
2. Are there significant differences between pre-service chemistry teachers' science process skills and their critical thinking skills scores based on gender and grade?
3. What is the relationship between pre-service chemistry teachers' science process skills and their critical thinking skills?.

METHODS

a) Research Design

A quantitative correlational research design aims to determine the relationship(s) between two variables and assess the existing correlation rate (Creswell, 2008). The current study included gender and grade as independent variables, while its dependent variables were science process skills and critical thinking skills.

b) Sample

This research was conducted at the Faculty of Mathematics and Natural Sciences of an Indonesian public university, on 1st - 24th November 2017. The sample consisted of 146 pre-service chemistry teachers (aged 18-20 years) (see Table 1). Whilst they were the first- and

the second-year of the study, they attended “General Chemistry Laboratory” and “Chemical Equilibrium Laboratory” courses, respectively. They were selected via a convenient sampling method, which prioritizes the availability of the sample to be involved in the study (Fraenkel, Wallen, & Hyun, 2012).

Table 1. *An outline of the sample’s characteristics*

Variables		<i>N</i>	Percentages
Gender	Male	47	32.2
	Female	99	67.8
	Total	146	100
Grades	First-Year	77	52.7
	Second-Year	69	47.3
	Total	146	100.0

c) Data Collection Tools

The Observation Checklist for Science Process Skills (OCSPS)

The OCSPS, developed by Irwanto, Rohaeti, and Prodjosantoso (2018b), was used to measure their performances during the foregoing laboratory courses. The OCSPS consists of 18 items (8 items for basic skills—observing, inferring, measuring, and communicating—and 10 items for integrated process skills—identifying and controlling variables, investigating, formulating hypotheses, experimenting, and interpreting data). Each item has a 4-point Likert scale (1 = unobserved, 2 = less observed, 3 = observed, and 4 = highly observed) (minimum and maximal scores are 18 and 72 points respectively). The highest score is accepted as an indicator of the student’s good science process skills during laboratory activities. The coefficient of Cronbach’s alpha reliability was found to be .88, which is higher than the acceptable value. That is, this means that the OCSPS was reliable for measuring pre-service chemistry teachers’ science process skills. Their science process skills were classified under 3 categories; low (<36 points), medium (36 – 54 points), and high (>54 points).

The Oliver-Hoyo Rubric for Critical Thinking (OHRCT)

Irwanto, Rohaeti, and Prodjosantoso (2018c) translated and adapted the OHRCT developed by Oliver-Hoyo (2003) into Indonesian. The OHRCT consisting of 6 dimensions (abstract, information sources, report organization, the relevance of ideas, report content, and written presentation) assesses students’ critical thinking skills through their written laboratory reports. A total of 13 senior lecturers modified and re-arranged the rubric as well as ensuring its face-validity. Then, it was pilot-tested with 134 pre-service chemistry teachers randomly selected from Yogyakarta, Indonesia. The Cronbach’s alpha reliability coefficient was counted to be .84. Because each dimension is scored from 1 point to 5 points, its minimum and maximal scores are 6 and 30 points respectively. The highest score is approved as an indicator of students’ critical thinking skills. Their critical thinking levels were categorized under 3 categories; low (<14 points), medium (14 – 22 points), and high (>22 points).

d) Data Analysis

Data were analyzed using SPSS 17.0™. Descriptive statistics were used for such parameters as mean, standard deviation, minimum score, maximal score, and percentage. Independent samples *t*-test was employed to determine any significant difference between pre-service chemistry students’ mean scores of gender and grade. Regression analysis was

computed to investigate any relationship between the dependent and independent variables. Pearson's correlation was exploited to explain any significant relationship between the variables. Strength and relationship between the variables were determined through Cohen's (1988) criteria; small ($r = .10$ to $.29$), medium ($r = .30$ to $.49$), and large effects ($r = .50$ to 1.00).

FINDINGS

The analysis results obtained in the survey are presented in this section. As seen in Table 2, pre-service chemistry teachers' science process skills ($M = 13.65$, $SD = 2.023$) and critical thinking skills ($M = 33.12$, $SD = 4.977$) were low.

Table 2. Descriptive results for students' science process skills and critical thinking skills

Variables	<i>N</i>	Min	Max	Mean	<i>SD</i>	Level
Science Process Skills	146	20	46	33.12	4.977	Low
Critical Thinking Skills	146	9	18	13.65	2.023	Low

As observed in Table 3, the results of independent samples *t*-test were used to examine any significant difference between their mean scores of science process skills and critical thinking skills in terms of gender and grade.

Table 3. The results of independent samples *t*-test for gender and grade

Dependent Variables	Independent Variables	<i>N</i>	Mean	<i>SD</i>	<i>p</i>
Science Process Skills	Male	47	29.57	4.712	.001
	Female	99	34.80	4.165	
	First-Year	77	29.84	3.321	.001
	Second-Year	69	36.77	3.851	
Critical Thinking Skills	Male	47	12.57	1.920	.001
	Female	99	14.16	1.872	
	First-Year	77	12.69	1.616	.001
	Second-Year	69	14.72	1.893	

Based on Table 3, there was a statistically significant difference between male and female pre-service chemistry teachers' mean scores of science process skills in favor of female ones ($p < .05$). Female pre-service chemistry teachers' mean score (5.23) was higher than that of male ones. Also, there was a significant difference between their mean scores of science process skills in terms of the first and second year of the study ($p < .05$). In this survey, freshman (the first-year of the study) pre-service chemistry teachers tended to have lower mean scores for science process skills as compared with sophomores (the second-year of the study) ones. In addition, a significant difference appeared between male and female pre-service chemistry teachers' mean scores of critical thinking skills ($p < .05$). Male pre-service chemistry teachers' mean score of critical thinking skills (1.59) was lower than that of female ones. A similar trend was also observed for gender. That is, pre-service chemistry teachers at the first-year of the study tended to have a lower mean score for critical thinking skills than those at the second-year of the study. The difference between mean scores of pre-service chemistry teachers at the first- and second-year of the study was statistically significant for critical thinking skills ($p < .05$). Overall, female pre-service chemistry teachers at the second-year of the study had higher scores for science process skills and critical thinking skills than male ones.

According to Table 4, the results indicated a positive and significant correlation between science process skills and critical thinking skills ($r = .793$, $p = .001$), between science process skills and gender ($r = .492$, $p = .001$), and between science process skills and grade (r

= .697, $p = .001$). Similar findings were found for critical thinking skills and gender ($r = .368$, $p = .001$), and critical thinking skills and grade ($r = .504$, $p = .001$). The results indicated that pre-service chemistry teachers, who had high scores for science process skills, tended to have high scores for critical thinking skills.

Table 4. *The results of Pearson's correlation analysis*

		Gender	Grade	Science Process Skills	Critical Thinking Skills
Gender	Pearson Correlation	1	.359**	.492**	.368**
	Sig.		.001	.001	.001
Grade	Pearson Correlation	.359**	1	.697**	.504**
	Sig.	.001		.001	.001
Science Process Skills	Pearson Correlation	.492**	.697**	1	.793**
	Sig.	.001	.001		.001
Critical Thinking Skills	Pearson Correlation	.368**	.504**	.793**	1
	Sig.	.001	.001	.001	

Note: **Correlation is significant at the .01 level (2-tailed).

To analyze any linear relationship between science process skills and critical thinking skills, multiple regression analysis was performed (see Table 5).

Table 5. *The results of multiple regression analysis*

Model	Unstandardized Coefficients		Standardized Coefficients	<i>t</i>	<i>p</i>
	<i>B</i>	Std. Error	β		
(Constant)	7.747	1.352		5.731	.001
Gender	2.446	.580	.216	4.214	.001
Grade	3.430	.522	.346	6.574	.001
Critical Thinking Skills	1.168	.124	.475	9.455	.001

a. Dependent Variable: Science Process Skills

As illustrated in Table 5, multiple linear regression analysis of all predictors was $R^2 = .784$, $F(3, 142) = 171.429$, $p = .001$. This means that multiple linear regression explained 78.40% of the data variance. All predictors were positively and significantly correlated with science process skills. These findings indicated that female pre-service chemistry teachers, who possessed higher grades and higher scores for critical thinking skills, tended to have higher scores for science process skills than male ones.

DISCUSSION

The results indicated that pre-service chemistry teachers' mean scores of science process skills and critical thinking skills were unsatisfactory. This may result from passive and teacher-centered learning. This is consistent with the results of Irwanto and Rohaeti (2016), who found that the students' low science process skills might come from the educators' low performances in constructing inquiry-based learning. Similarly, Prayitno, Corebima, Susilo, Zubaidah and Ramli (2017) stated that conventional teaching method had a low capacity at improving students' science process skills. Previous evidence claimed that low critical thinking and science process skills could be enhanced through non-traditional teaching methods (Duran & Dökme, 2016; Kek & Huijser, 2011; Yakar & Baykara, 2014).

Similar results were also found in previous studies (e.g., Beaumont-Walters & Soyibo, 2001; Chaiyen, Bunsawansong, & Yutakom, 2007; Foulds & Rowe, 1996; Irwanto et al., 2017). These studies describe that students' science process skills tend to be poor. Likewise, Seetee and Dahsah (2017) found that inferring, predicting and formulating hypotheses skills were considered low. In fact, science process skills deal with hands-on activities. If students' science process skills were low, it may be due to their lack of experience in inquiry-based laboratory courses. Supportively, Lati, Supasorn, and Promarak (2012) explained that there was a relationship between weak performance and investigative activities. Because of the relationship between these two variables, Karamustafaoğlu (2011) asserted that science process skills could be improved through active laboratory work.

Furthermore, Fuad, Zubaidah, Mahanal and Suarsini (2017), Hapsari (2016) and Jatmiko et al. (2018) found that the students' critical thinking level tended to be unsatisfactory. This may stem from their low competency levels that cause a monotonous learning process and less optimal implementation. In a similar vein, Bulgurcuoglu (2016) considered that the availability of adequate methods, techniques, and teaching materials might develop students' knowledge/conceptions. Therefore, students' low science process skills and critical thinking skills need to be improved through laboratory activities. Instead of performing cookbook procedures, students are capable of designing, conducting, communicating, and evaluating each experiment. This argument was supported by Feyzioglu (2009) who argued that the confirmatory laboratory method only activates low-level skills. In a similar way, Roth and Roychoudhury (1993) expressed that students' science process skills reach the highest level when they conduct scientific experiments in meaningful contexts.

As seen in Table 3, the results of independent samples *t*-test revealed a significant difference between male and female pre-service chemistry teachers' mean scores of science process skills in favor of female ones. For grades, there was a significant difference between their mean scores of science process skills in favor of the pre-service chemistry teachers at the second-year of the study. Consistent with previous studies, there was a significant difference between males and females in mastering science process skills (Ongowo, 2017; Zeidan & Jayosi, 2015). Several studies found that science process skills score of female students were higher than those of males (Aydinli et al., 2011; Karar & Yenice, 2012). We argued that the females' high process skills score is related to their interest in laboratory activities. Dhindsa and Chung (2003) also revealed that females prefer chemical laboratory activities more than males. In the light of the findings, there was a significant difference in the mastery of science process skills based on grade (Dirks & Cunningham, 2006; Aydoğdu & Buldur, 2013; Ong et al., 2015; Ongowo, 2017; Saat, 2004). They agreed that students on a higher grade level would get higher science process skills score. The high performance of second-year students is made possible by the acquisition of more experiences and knowledge than the first-year students.

In addition, the current study found a significant difference between male and female pre-service chemistry teachers' mean scores of critical thinking skills in favor of female ones. Also, there was a significant difference between grades' mean scores of critical thinking skills in favor of pre-service chemistry teachers at the second-year of the study. Pre-service chemistry teachers with a higher grade performed better than those with a lower grade. Previous evidence confirmed that there was a significant difference between critical thinking based on gender (Dilekli, 2017; Fuad et al., 2017; Kim, Moon, Kim, Kim, & Lee, 2014; King, Wood, & Mines, 1990; Tarawneh, 2016). Similar results were also found by Güleç (2010), Rudd and Moore (2003) and Serin, Serin, Saracaloglu, and Ceylan (2010) which showed that females' score tends to be higher than males'. Supportively, our current findings reinforce previous claims that gender influences critical thinking. We also found a significant difference in critical thinking score by grade. Students' score on higher-grade was better than

lower-grade students. This finding was in line with previous studies (e.g., Babamohamdi & Khalili, 2005; Ibrahim, 2016; Tmkaya, Aybek, & Aldađ, 2009). The results indicated that various factors (e.g., pre-service chemistry teacher's age) influenced an increase in their scores of critical thinking skills. As students get older, their critical thinking also increases (Dođanay, Akbulut-Taş, & Erden, 2007; Dunn, Rakes, & Rakes, 2014).

As observed in Tables 4 and 5, the results of correlation and regression analysis showed a significantly high positive correlation between science process skills and critical thinking skills. It can be concluded that an increase in their science process skills enhances their critical thinking skills. This conclusion is in a parallel with that of Rohani (2013) reporting a high correlation between these variables through inquiry-based learning. Supportively, Khaeruddin, Nur and Wasis (2016) also found a correlation between critical thinking and science process skills in physics learning. Furthermore, Nugraha, Suyitno, and Susilaningasih (2017) also informed a high correlation between students' critical thinking and science process skills in the experimental group. In contrast, Akar (2007) found a low correlation between these variables. Such slightly different results may come from students' differences in learning styles (Dilekli, 2017). In essence, developing science process skills intends to enhance students' critical thinking skills (e.g., Erkol & Ugulu, 2014).

CONCLUSION and SUGGESTIONS

The current study provided an overview of pre-service chemistry teachers' science process skills and critical thinking skills in chemistry laboratory courses and the relationship(s) between these variables based on gender and grade. The findings pointed out that pre-service chemistry teachers' mean scores of science process skills and critical thinking skills were unsatisfactory. There was a statistically significant difference between their mean scores of gender ($p < .05$). Females had higher mean scores for science process skills and critical thinking skills than males. Additionally, there was a significant difference between grades' mean scores of science process skills and critical thinking skills ($p < .05$). Pre-service chemistry teachers at the second-year of the study tended to have higher mean scores for science process skills and critical thinking skills than those at the first-year of the study. Similarly, the correlation and regression analysis also showed a significantly high positive correlation between science process skills and critical thinking skills ($r = .793$; $p = .001$). It can be deduced that an increase in critical thinking skills results in an increase in science process skills.

As a suggestion, educational programs and pedagogical practices need to improve students' performance through laboratory work. Students need to be given challenging tasks and actively involved in discoveries supported by research-oriented collaborative inquiry learning. Through this teaching method, students are expected to be more active in laboratory practices; thus, it contributes positively to developing generic skills and their attitudes. In light of the results, the current study recommends that universities should prepare students to critically think and equip them with science process skills at satisfactorily. By doing this, enhancing the quality of graduates properly meets the workforce. Also, future research ought to test the effectiveness of certain teaching methods on critical thinking skills and science process skills. Finally, there are some limitations in this study. In current quantitative research, we use a cross-sectional design; thus, longitudinal studies can be employed to obtain more comprehensive findings. In addition, this survey was only conducted at a university; thereby, this finding cannot be generalized to all pre-service chemistry teachers in Indonesia.

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