The investigation on university students' science process skills and chemistry attitudes at the laboratory course

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Abstract

It is important to enable the students to have the scientific skills and attitudes which are well developed in order that students can be competitive in the global society, however, it appears that many students are lacking these required competences. As such, this research aims to investigate the Science Process Skills (SPS) and Chemistry Attitudes (CA) and analyze the correlation between those two variables. Convenience sampling was executed to select 152 undergraduate chemistry students at the Yogyakarta State University in the academic year 2017/2018. This survey involved quantitative method and correlational design. The data were obtained by using Science Process Skills Observation Checklist (SPSOC) and Attitudes towards Chemistry Scale (ATCS). The Cronbach's alpha reliability coefficient of each instrument was .88 and .84 respectively. The descriptive statistic, T-test, Pearson correlation, and regression analysis were used at significance level .05. Based on the findings, students' SPS and CA were classified low and moderate respectively. There was significant difference between SPS and CA scores based on gender in favor of female students. Additionally, there was significant difference between students' SPS and CA scores based on grade levels in favor of second-year students. According to the result of the correlation and regression analysis also showed a high positive and significant correlation between SPS and CA. It can be concluded that students who have high SPS score tend to have positive attitudes towards chemistry. Implications of the findings on the pedagogical practices have been discussed.

Keywords: chemistry attitudes, laboratory course, science process skills, university students

Introduction

Chemistry learning aims at developing students' professionalism and facilitating them to compete in the global society. One of the essential skills need in the 21st century chemistry learning is science process skills (Chabalengula, Mumba, & Mbewe, 2012; Sermsirikarnjana, Kiddee, & Pupat, 2017). Science process skills are a key aspect in learning scientific knowledge because the scientific knowledge is obtained through the investigation results (Sa-ngiamjit, 2016). Science process skills enable the students to be directly involved in the science materials when solving the problem by using scientific approach (Abungu, Okere, & Wachanga, 2014). The students who have process skills tend to think analytically and able to solve the new problem compared to the students who do not have process skills (Oloyede, 2012).

Science process skills generally used in the learning which is designed to involve the students conducting investigation, one of them is chemistry.

Generally, chemistry contains abstract concepts that require good reasoning skills. In other words, chemistry concepts require the students to integrate the three levels of representation, i.e., macroscopic, microscopic, and symbolic (Herga, Čagran, & Dinevski, 2016; Santos & Arroio, 2016). The interaction among those three levels is an important characteristic needed to understand the chemistry concepts (Sirhan, 2007). Therefore, learning chemistry is not only about learning how many materials to be remembered but also learning to acquire science process skills and then apply them in scientific investigation (Jeenthong, Ruenwongsa, & Sriwattanarothai, 2014). Through science process skills, the students are expected to be able to solve the problem that they encounter inside and outside of the laboratory (Bolat, Türk, Turna, & Altinbaş, 2014; Çam, Topçu, & Sülün, 2015; Irwanto, Rohaeti, Widjajanti, & Suyanta, 2017). In sum, Science Process Skills (SPS) are needed by the students to learn to become a researcher.

A number of previous studies on SPS have been conducted in various contexts. In Turkey, Aktamis and Ergin (2008) investigated the effect of SPS-based teaching to improve students' scientific creativity, attitudes towards science and science achievement involving 40 seventh grade students as the samples. The result showed that SPS have been known to be able to improve students' learning achievement and creativity. Earlier before, O'Brien and Peters (1994) examined the influence of cooperative learning in the form of microcomputer-based teaching on the learning achievement of 165 preservice elementary teachers. It is found out that students' process skills have a moderate influence on their cognitive development. Recently, in Indonesia, Prayitno, Corebima, Susilo, Zubaidah and Ramli (2017) analyzed the influence of Inquiry-based Learning and Student Team Achievement Division (INSTAD) on science process skills involving 136 seventh grade students which result indicated a correlation between students' academic skills and science process skills. It is found out that students with higher academic skills tend to obtain significantly better SPS compared to those with lower academic skills.

SPS are frequently linked with hands-on laboratory activities (Durmaz, 2016; Seyhan, 2015; Taylor, Rogers, & Veal, 2009). In other words, the chemistry laboratory serves as a place for developing students' intellectual, mental, and psychomotor skills through discovery activities. In practice, it turns out that students do not only need to be sufficiently equipped with skills, but also need to have a Chemistry Attitudes (CA) to support the investigative activities in the laboratory. Osborne (2003) pointed that students' attitudes are the result of their experience in science. Attitudes relate to ideas, beliefs, and honesty in reporting, and skepticism (Jones & Butts, 1983). As stated by Lang, Wong and Fraser (2005), there is a significant association between students' attitudes towards chemistry and their laboratory class environment. Attitudes are used to provide direction to scientific actions. One of the factors influencing students' attitudes towards chemistry is students' involvement in the learning process (Kubiatko, 2015). Lack of judgment on students' attitudes are one of factors that triggers their poor scientific orientation and their low responsible attitudes in their daily activities (Ataha & Ogumogu, 2013). Therefore, evaluating students' attitudes periodically is one of the important factors in improving success in chemistry learning.

Another goal of chemistry learning at tertiary level is to develop positive attitudes. Ajzen (2001) expressed that attitudes relate to the attribute such as good-bad, beneficial-unhelpful, pleasant-unpleasant, and like-dislike which are relatively stable over time. Attitudes are considered as one of particular attitudes in science which is described as the way followed by the scientists in accessing and interpreting the knowledge (Yaşar & Anagün, 2009). Scientific attitudes are classified into eight components, such as rationality, curiosity, open-mindedness, objectivity, aversion to superstition, suspended judgment, critical mindedness, intellectual honesty, and humility (Billey & Zakhariades, 1975; Gauld & Hukins, 1980; Önder, Çelik, & Silay, 2012). Scientific attitudes are viewed as the process which connects stimulus and responses towards the students' behavior (Heng & Karpudewan, 2015). If the students have positive attitudes, they are predicted to be more successful in achieving the achievement and pursue their career (Aydeniz & Kaya, 2012; Kubiatko, Balatova, Fancovicova & Prokop, 2017).

Scientific attitudes refer to the phenomenon on how the students think, feel, and perform logical and systematical actions (Cavas, Ozdem, & Cavas, 2013; Kapici & Akçay, 2016; Montes, Ferreira, & Rodríguez, 2018; Schwarz, 2007). Several previous research indicate that scientific attitudes are extremely needed in learning. Scientific attitudes are one of factors that motivate the students (Al-Rabadi, Al-Momani, & Al-Rabadi, 2013) and simultaneously determine student achievement in science learning (Ali, Iqbal, & Akhtar, 2015; Brown et al., 2015; Gonen, 2008; Salta & Tzougraki, 2004). Even Bakar et al. (2010), Gardner (1975) and Osborne (2003) considered attitudes as the most influencing factor towards the achievement among other factors. The students who have scientific attitudes show willingness to understand, question, find out and verify the data and considering the consequences (Akcay, Yager, Iskander & Turgut, 2010). Therefore, scientific attitudes would lead the students to think critically, develop their curiosity, and able to distinguish between facts and opinions, and dare to argue.

Within the context of science, especially chemistry, attitudes share vital relationships with other factors. Brown et al. (2015) involved 125 university students to find out the correlation between their attitudes towards chemistry and their learning achievement. It is found out that even at a weak level, there is a positive correlation between students' affective scores and achievement in low-achievement group. Furthermore, Kurbanoglu and Akin (2010) also found out that chemistry laboratory anxiety negatively correlates with students' attitudes on chemistry and self-efficacy. Besides, it is also reported that attitudes on chemistry share a positive correlation with self-efficacy. In Turkey, Hacieminoglu (2016) also involved 3598 seventh grade students to examine the correlation between attitudes in science and other variables. The result showed that students' attitudes towards science has a strong positive correlation with performance-goal orientation, learning goal orientation, self-efficacy, meaningful learning, and rote learning. In addition, a moderate correlation between students' attitudes towards science and science achievement, and nature of science views were also successfully confirmed. Meanwhile, in Philippines, Magwilang (2016) conducted a study to examine the effect of context-based approach toward students' motivation, attitudes and achievement in inorganic chemistry lesson. The result showed that students in the experimental group had higher motivation, positive attitudes and higher achievement than students in the control group. Furthermore, Usak et al. (2009) explored students' attitudes towards science at 1301 university students which result showed that there was a statistically significant correlation between attitudes and achievement. It was also found out that male students obtained slightly identical average scores to the female students'.

In addition to those variables, attitudes towards science are known to be influenced by other predictors, such as gender (Gardner, 1975; Heng & Karpudewan, 2015; Osborne, 2003; Özyürek & Eryilmaz, 2001; Weinburgh, 1995) and grade levels (George, 2006; Hacieminoglu, 2016; Heng & Karpudewan, 2015). Accordingly, Osborne (2003) highlighted that the most significant factor which influences students' attitudes towards science is gender. In another word, attitudes should be acquired by the students in solving various problems that occur in chemistry experiments. The problem solving should also be supported by adequate SPS. In a study administered by Downing and Filer (1999), a positive correlation was found between preservice elementary teachers' science process skills and their attitudes towards science. Similarly, Yakar (2014) also argued that positive attitudes towards science could be enhanced through activation of science process skills.

We claim that adequate SPS and positive chemistry attitudes support students' achievement in solving unstructured problems. Unfortunately, in Indonesia, only few studies on students attitudes (e.g., Kristiani, Susilo, & Aloysius, 2015; Suprapto & Mursid, 2017; Suryawati & Osman, 2018) and SPS (e.g., Prayitno et al., 2017; Rani, Wiyatmo, & Kustanto, 2017; Subali, Paidi, & Mariyam, 2016) available. Moreover, previous studies have not yet tapped on the correlation between SPS and attitudes in students majoring chemistry. We also strongly believe that positive attitudes and cognitive skills help students to evaluate and decide in solving various problems related to chemistry (Erdem, 2015). Therefore, it is important for researchers to investigate the extent to which student competence has been achieved in chemistry learning. Such research is made as an effort to provide educators with information to improve and enhance the success of learning programs to come.

Motivation and Objectives

In the curriculum of higher education in Indonesia, it is important to integrate scientific skills and chemistry attitudes into chemistry teaching and learning, including laboratory courses. It is for minimizing the dominance of conventional lectures. We assume that this approach is effective in enhancing students' psychomotor and affective through various practical works. In order to improve students' performance, lecturers need to be a mediator in training soft skills into hard skills. This approach is also believed to be able to promote creative thinking, communication, collaboration, and critical thinking skills, because students are faced directly with unstructured problems in their daily life. Based on these issues, this study is intended to:

- map the students' performance in order to make the lecturers able to plan learning programs to develop process skills and attitudes towards chemistry;
- implement laboratory learning strategies that do not only enhance understanding of chemistry concepts, but also promote various practical skills and chemistry attitudes that students require to solve problems in the 21st century; and
- apply certain laboratory teaching methods that can improve students' performances through laboratory work;

When the students are trained to master science process skills, it can lead to improving the quality of graduates and enhancing educational programs at tertiary level. This effort is considered as a mediator to link the teaching and the research in higher education.

The Objectives of the Study

The purposes of this study are to: 1) investigate the level of students' SPS and CA, 2) examine the differences between the average SPS score and CA score of students based on gender and grade levels, and 3) explore the relationship between SPS and CA among undergraduate chemistry students. The main questions of this study are:

- How is the level of students' SPS and CA in chemistry study program?
- Are there any significant differences of students' mastery in SPS based on gender and grade levels?
- Are there any significant differences of students' mastery in CA based on gender and grade levels?
- How is the relationship between students' SPS and CA in chemistry study program?

Methodology

Research Design

This research used quantitative method and correlational design. The quantitative data were collected by using survey technique. Correlational research design was used to express the relationship between quantitative variables that had not been manipulated (Fraenkel, Wallen, & Hyun, 2012). Independent variables were gender and grade levels, while the dependent variables were SPS and CA scores. This study was conducted at the end of the academic year when the students had completed all experiments. It was for exploring the students' mastery of SPS and CA then evaluating the effectiveness of laboratory method that had been applied in one semester. These results can be used as a foundation for lecturers in increasing SPS and developing CA of the students using other laboratory approaches that were considered more effective and efficient.

Participants

The participants in the main study were 152 undergraduate chemistry students at the Faculty of Mathematics and Natural Sciences, Yogyakarta State University, Indonesia. There were 75 first-year students attended the General Chemistry Laboratory course and 77 second-year students enrolled in the Analytical Chemistry Laboratory course (see Table I). First-year students carried out the Reaction Rate experiment and second-year students carried out the Gravimetric Analysis experiment. All respondents completed the experiment according to the instructions which had been prepared by the lecturer. During the observation, researchers did not provide any intervention to the participants. Participants (age between 18-20 years old) took part in lectures in odd semester academic year 2017/2018. The sampling technique used the convenience sampling. Creswell (2008) mentioned convenience sampling as when researchers selected participants because they were willing and readily available.

Table I. Distribution of Participants

Gender	**N**	**Percentage**
Male	54	35.5
Female	98	64.5
Total	152	100
Grade Levels		
First-Year	75	49.3
Second-Year	77	50.7
Total	152	100

Data Collection Instruments

Science Process Skills Observation Checklist (SPSOC): SPSOC developed by Irwanto, Rohaeti and Prodjosantoso (2018) was used to measure the students' science process skills during the chemistry laboratory course. SPSOC consisted of 18 statments, including 8 items of basic process skills (44.44%) and 10 items of integrated process skills (55.56%). The basic SPS included observing, inferring, measuring, and communicating. Whereas integrated SPS included identifying and controlling variables, investigating, formulating hypotheses, conducting an experiment, and interpreting data. Each item had a 4-point Likert scale (4 = highly observed to 1 = unobserved) which the highest score indicates that the students have good science process skills during laboratory activities. The minimum and maximum possible scores obtained by each student were 18 and 72 points respectively. In the pilot study, the instrument was tested to 176 randomly selected undergraduate chemistry students in Yogyakarta. The coefficient of Cronbach's alpha reliability was 88. It showed that SPSOC was reliabel to measure the students' science process skills. The students' SPS were stratified into 3 levels; low (<36 points), moderate (36-54 points), and high (>54 points).

The following statements were the examples of SPSOC:

Observing the objects using all the senses

Recording the observations according to their characteristics

Reading the measurement results accurately

Presenting data in the form of tables, graphs, or diagrams

Identifying the independent, dependent, and controlled variables

Choosing the appropriate design to test the hypothesis

Formulating the hypotheses that can be tested for truth

Drawing the conclusions based on a series of investigations

Attitudes towards Chemistry Scale (ATCS): ATCS designed by researchers was administered to measure students' attitudes towards chemistry. ATCS consisted of 9 subscales which were elaborated into 36 statements (18 positive and 18 negative). The subscale included rationality, curiosity, open-mindedness, objectivity, aversion to superstition, suspended judgment, critical mindedness, intellectual honesty, and humility. Each subscale consisted of 4 statements (2 positive and 2 negative), where each item had a 4-point Likert scale (4 = strongly agree to 1 = strongly disagree). Negative statements were scored in the opposite direction. The minimum and maximum scores possible to be obtained by each student were 36 and 144 points respectively. In the pilot study, the instrument was tested to 145 randomly selected undergraduate chemistry students in Yogyakarta. The coefficient of Cronbach's alpha reliability was 84. It showed that ATCS was reliable for measuring students' attitudes towards chemistry. Students' attitudes were classified into 3 levels; low/negative (<72 points), moderate/neutral (72-108 points), and high/positive attitudes (>108 points).

The following statements were the examples of ATCS:

I plan an experiment systematically
I would like to make science perfect through chemistry experiments
I observe accurately
I do not acknowledge newer and more relevant theories on chemistry
I am learning to be a chemist
I report the investigation's result honestly
I think laboratory activities help me comprehend how chemistry influences our daily life
I interest to continue the habit of researching outside of lectures

Procedures

The survey was conducted in November 2017 after obtaining official permission from the Head of the Department of Chemistry Education, Yogyakarta State University, Indonesia. The researchers conducted a survey for the first-year students taking the General Chemisty Lab course and second-year students who took the Analytical Chemistry Lab course. The first day, the researchers conducted an observation for 100 minutes by using SPSOC, while the second day the students completed the ATCS for 50 minutes. Before distributing ATCS, the researchers explained the purposes and objectives of the study to students that this study had no effect on their learning outcomes. In the study, student position was only as a participant. Participants were asked to complete the questionnaire, which was given once at the end of the experiment. Finally, ATCS was collected to the researchers for administrated and then analyzed.

Data Analysis

SPSS 17 (SPSS Inc., Chicago, IL, USA) was performed to analyze data obtained from both instruments. Descriptive statistics were used to test the mean and standard deviation. After fulfilling the normality assumption ($p > .05$), the T-test was employed to determine the difference between SPS and CA scores between male and female students at the .05 significance level. Pearson's correlation was conducted to explain the significance of relationships between variables. The strength of the relationship between variables was determined using Cohen's (1988) correlation coefficient. These criteria were categorized into small (r = .10 to .29), medium (r = .30 to .49) and large effects (r = .50 to 1.00). Finally, regression analysis was executed to express the relationship between SPS and CA.

Findings

Students' performance was specifically described in this section. Both SPS and CA students were compared by gender and grade levels. Further, the SPS and CA scores of undergraduate chemistry students were presented in Table II. As presented in Table II, students' average SPS score (M = 35.03, SD = 6.187) was considered low level. While their average CA score (M = 97.91, SD = 10.035) was classified as moderate (neutral attitudes).

Table II. SPS and CA Level of Students

Variables	N	Min	Max	Mean	Std.Deviation	Level
Science Process Skills	152	18	45	35.03	6.187	Low
Chemistry Attitudes	152	75	120	97.91	10.035	Moderate

After cognizing the level of students' competence, the T-test was calculated to examine whether there were significant differences between students' average SPS and CA scores based on gender and grade levels.

Table III. Differences between Students' SPS and CA

Dependent	Independent	N	Mean	Std.Deviation	*p*
Science Process Skills	Male	54	29.50	3.908	.000
	Female	98	38.08	4.982	
	First-Year	75	29.87	3.685	.000
	Second-Year	77	40.06	3.294	
Chemistry Attitudes	Male	54	91.28	6.864	.000
	Female	98	101.57	9.643	
	First-Year	75	91.28	6.569	.000
	Second-Year	77	104.38	8.504	

As can be seen in Table III, there was a statistically significant difference ($p<.05$) between students' average SPS score based on gender in favor of females. The male students were 8.58 points lower in mean SPS score than the females. Furthermore, there was also a statistically significant differences ($p<.05$) between average SPS score based on grade levels in favor of second-year students. According to the study, second-year students tended to have a higher average SPS score of 10.19 points compared to first-year students.

In the case of chemistry attitudes, a significant difference in mean score ($p<.05$) between males and females was also found. The male students were 10.29 points lower in mean CA score than the females. Similar results were also shown by first-year students who tended to have a lower average CA score of 13.10 points compared to second-year students. Statistically, there was a significant difference ($p<.05$) between CA scores for first-year and second-year students. In general, Table III informed that the female students in the second-year (code 1 = male, 2 = female, 1 = first-year, 2 = second-year) are higher in SPS and CA scores compared to males.

To answer the last research question, the Pearson's Correlation (see Table IV) was employed to determine the causal relationship between variables.

Table IV. The Results of the Pearson's Correlation Analysis on All Variables

		Gender	Grades	Science Process Skills	Chemistry Attitudes
Gender	Pearson Correlation	1	.670**	.666**	.493**
	Sig. (2-tailed)		.000	.000	.000
Grades	Pearson Correlation	.670**	1	.827**	.655**
	Sig. (2-tailed)	.000		.000	.000
Science	Pearson Correlation	.666**	.827**	1	.824**

Process Skills	Sig. (2-tailed)	.000	.000		.000
Chemistry Attitudes	Pearson Correlation	.493**	.655**	.824**	1
	Sig. (2-tailed)	.000	.000	.000	
*Note: **. Correlation is significant at the .01 level (2-tailed).*					

As seen in Table IV, there was a high positive and significant correlation between SPS and CA (r = .824, p = .000), gender (r = .666, p = .000), and grade levels (r = .827, p = .000). The results of the study also informed that there was a positive correlation between CA and gender (r = .493, p = .000) and grade levels (r = .655, p = .000). In addition, the linear relationship between SPS and CA was also confirmed by regression analysis which produced R2 = .679, F(1, 150) = 316,717, p = .000. It meaned that the linear regression explained 67.90% of the variance in the data. Accordingly, the findings indicated that students who got a high SPS score tended to show a positive attitudes towards chemistry in laboratory course.

Discussion

The study was conducted to investigate the level of SPS and CA, examine the differences between the average SPS and CA scores of students in terms of gender and grade levels, and explore the relationship between SPS and CA among undergraduate chemistry students. Based on the results, it can be explained that the average SPS and CA scores of chemistry students were considered low and moderate respectively. This probablly related to learning activities and methods applied in lectures. All this time, lectures in chemistry laboratories tended to take advantage of cookbook procedures, where students followed step-by-step. As such, we claimed that this was one of the factors causing students' low process skills and attitudes. In Turkey, Durmaz and Mutlu (2014) confirmed that the average increase in science process skills of students taught using conventional learning tended to be low. We argued that the learning environment and the selection of appropriate learning strategies were the key in improving students' SPS and CA. Hacieminoglu (2016) also suggested that the learning environment needed to be designed to enable students to achieve scientific knowledge and positive attitudes.

Several previous studies have also found similar results. Irwanto et al. (2017), Irwanto, Rohaeti and Prodjosantoso (2018), Kalemkuş, Bayraktar and Kalemkuş (2016) and Lati, Supasorn and Promarak (2012) reported that students' SPS still tended to be poor. In addition, Gobaw and Atagana (2016) noted that one of sub-skills in SPS, i.e., measuring, was also low. Moreover, Ismail and Jusoh (2001) also found the low result of SPS in identifying variables. The low of students' SPS was predicted because they were seldom involved directly in determining the solustion of a problem, less optimization of learning which involved the students' role, and lecturers activity still focused on transferring concept. We suggested to create an active learning by using discovery strategy. Supportively, Akben (2015) found that inquiry-based learning can effectively increase SPS. Furthermore, Yunus and Ali (2013) also pointed that majority of respondents had a positive attitudes towards chemistry when they conducted experiments.

Whereas, the other researchers who had a reseach about students' chemistry attitudes also reported the unsatisfy results. Kubiatko, Balatova, Fancovicova and Prokop (2017) and Salta and Tzougraki (2004) informed that students' attitudes towards chemistry tended be negative to neutral. We have predicted that the less positive attitudes of students because of having teacher-centered learning, students' investigative activities being rarely done, and the learning being more result-oriented than process-oriented. Yunus and Ali (2013) revealed that the students did not show positive attitudes towards chemistry when they were asked listening the lesson that explained by the teacher. It showed that the students preferred to engage in hands-on or student-centered learning activities. In this case, Lang et al. (2005) emphasized the important of interaction among students, students-teacher, and students-learning environment to increase scientific attitudes. We believed that learning environment design that permitted students to make discoveries could provide them more experince. Additionally, Freedman (1997) concluded that laboratory instruction positively affects students' attitudes towards science. It was because a laboratory made a science be more interesting and encouraged students to conduct an investigation.

A significant difference between average SPS and CA scores of students based on gender and grade levels are presented in Table III. Based on the results of the T-test, it is found there was a significant difference between the average SPS score based on gender in favor of female students. It was in line with the results of previous studies which agree that there were significant differences between male and female in mastering SPS (e.g., Akbaş, 2010; Eya, 2016; Gürses, Çetinkaya, Doğar, & Şahin, 2015; Ogura & Takemura, 1994). Several previous studies also found that female SPS score was higher than male (Karar & Yenice, 2012; Shaibu & Mari, 2003). It may be because female had a higher interest and motivation for chemistry. This argument was also in line with the results of the study of Akram, Ijazand Ikram (2017).

In the case of grade levels, the results of the current study revealed that significantly second-year students had a higher mean SPS score than first-year students. The low performance of first-year students allowed their lack of experience in laboratory activities. Current research was relevant to previous research findings (e.g., Delen & Kesercioğlu, 2012; Gürses et al., 2015; Ong et al., 2015). At the undergraduate general chemistry laboratory, Cengiz and Karataş (2015) and Taylor et al. (2009) surprisingly found that most students did not recognize laboratory equipment; and science process skills and their self-esteem were low. Other studies also agreed that students in higher grades showed higher performances (Beaumont-Walters & Soyibo, 2001; Ong et al., 2015; Özgelen, 2012). The high SPS scores of second-year students were related to their cognitive development in building knowledge and experience. As a result, second-year students at Analytical Chemistry Lab course had higher scores than first-year students at the General Chemisty Lab course. For this reason, we predicted that the superiority of second-year students was possible because they had more laboratory work experience. Implicitly, Germann (1994), Lee (1993) and Oloyede (2012) revealed that students with higher levels of cognitive development tended to have higher process skills. Supportively, Hodson (2005) and Pernaa and Aksela (2009) also emphasized that practical work equips students with various experiences in solving problems, developing laboratory skills, and promoting positive attitudes.

In the context of the affective domain, our study found a significant difference between the average CA score of students based on gender in favor of females. Furthermore, it also found a significant difference between the average CA score based on grade levels in favor of second-year students. Several previous studies described the similar results to the current study that there was a significant difference between the average CA score by gender (Can, 2012; Chen & Howard, 2010; Gardner, 1975; Taşdemir & Kartal, 2013). Similar results were also found by Abu-Hola (2005), Anwer, Iqbaland Harrison (2012), Chuang and Cheng (2002) and Dhindsa and Chung (2003) which showed that females had a more positive attitudes towards science than males.

Significantly, we also found the difference in average CA score based on grade levels. The average score of high-grade students was better than low-grade students. This finding was in line with previous studies (e.g., Can, 2012; Erdogan, 2017; Peer & Fraser, 2015; Taşdemir & Kartal, 2013; Weinburgh, 1995). These results indicated that an increase of CA score was influenced by various factors, i.e., experience, knowledge and emotional constructs during learning. It was in accordance with Erdogan's (2017) opinion which revealed that upper-level students had taken various courses so that they indirectly influenced their attitudes towards science.

Based on correlation and regression analysis, it showed a high positive and significant correlation between SPS and CA. It could be concluded that the increase of SPS score would increase student CA score. It meaned those students who had a high SPS score tended to have a positive attitudes towards science. In line with the results of the current study, Lee (1993) compared cognitive development, SPS, and attitudes towards science among prospective teachers with different backgrounds in China. There was a significant correlation between SPS and attitudes towards science ($r = .21$; $p<.001$). In other studies, Zeidan and Jayosi (2015) also asserted the significant relationship between SPS and attitudes towards science ($r = .69$; $p = .03$).

Moreover, Downing and Filer (1999) investigated the relationship between SPS prospective teachers and attitudes towards science. The study found a significant positive relationship between SPS levels and attitudes towards science ($r = .39$; $p = .05$). Furthermore, Al-Rabadi et al. (2013) also highlighted that scientific attitudes were a factor that influenced students in acquiring science process skills. In fact, Bakar et al. (2010) mentioned that scientific attitudes were seen as a factor that had the greatest influence among other factors. We viewed that SPS and CA were two important aspects that could not be separated in chemistry learning. In line with that argument, Yaşar and Anagün (2009) suggested that in learning science, educators needed to guide students to obtain science process skills and scientific attitudes.

Conclusion and Suggestions

The study found that the average SPS and CA scores of undergraduate chemistry students were considered low and moderate respectively. In this survey, we reported a statistically significant difference between the average SPS and CA scores based on gender in favor of female students. It means that lecturers must arrange laboratory activities on the basis of gender differences so that each student had the opportunity to develop SPS and a positive attitudes towards chemistry. Interestingly, the stereotype "male are stronger than female" was not found in this study. Furthermore, there were significant differences between SPS and CA scores based on grade levels in favor of second-year students. It means that students' laboratory work experience in higher levels influence their practice skills and attitudes. Based on correlation and regression analysis also showed a high positive and significant correlation between SPS and CA. It can be concluded that students who have a high SPS score tend to have a positive attitudes towards chemistry.

The implication is that before starting the laboratory course, lecturers need to diagnose students' initial science process skills and chemistry attitudes. Afterwards, lecturers plan learning in such a way that they can help improve students' skills and develop attitudes. One effort is to design chemistry laboratory work or methods to the desired level that they consider satisfying. Given the importance of these two domains, we suggest that lectures facilitate students to carry out various hands-on activities and solve problems related to the real world. Furthermore, the educational practices need to be transformed toward how to design effective teaching methods, create a conducive learning environment, and stimulate interesting lecture activities to promote students' SPS and CA.

The limitation of this study is that the respondents involved are limited. As a reference for future research, the researchers are encouraged to expand this survey by adding more samples to make stronger claims. In addition, this study is a cross-sectional conducted at two chemistry laboratory courses at a university. Different findings can be obtained in longitudinal study involving a wider sample, including branches, grades, and other lectures in the science fields. As a follow up, it is necessary to investigate how to develop SPS and CA among university students using inquiry-based laboratory instruction. Current research contributes to bridging the importance of further research on how to improve learning outcomes in chemistry laboratory courses that are rarely investigated.

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