

UNDERGRADUATE STUDENTS' SCIENCE PROCESS SKILLS IN TERMS OF SOME VARIABLES: A PERSPECTIVE FROM INDONESIA

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Introduction

In Indonesia, the teaching of chemistry is intended to make students grow adequate competences in chemistry by teaching them the knowledge and skills that are deemed necessary, as well as to develop positive attitudes related to chemistry needed when faced with unfamiliar situations (MRTHE, 2015). In the teaching of chemistry, students should be engaged in hands-on authentic experiences to discover scientific facts. The advancement of technology has expanded the objectives of chemistry teaching not only to develop the students' understanding of the chemistry concepts, but also to teach them how to use the knowledge to solve real-life problems (Su, 2016; Wood, 2006; Živkovic, 2016). Thus, students are required to collect relevant information to be analyzed and interpreted in order to find the intended solutions by means of implementing sound scientific processes. Modern teaching of chemistry also demands the students to be more actively engaged in the teaching and learning process, instead of passively receiving the knowledge from lecturers (Henry, 2017; Paulson, 1999). It is expected that students master various advanced chemistry skills and by doing so assist to provide positive contributions to the global society.

There are a number of skills applied in chemistry learning, one of which is science process skills. It refers to the skill used in understanding and investigating certain problems relevant to scientific phenomena (Bilgin, 2006; Feyzioğlu, 2009). In addition, these skills also relate to the skills that demand students to think and act like scientists (Ergül, Simsekli, Çalis, Özdilek, Göçmençelebi, & Sanli, 2011; Prayitno, Corebima, Susilo, Zubaidah, & Ramli, 2017). SPS also engage the students to actively participate and hold the responsibility to learn various scientific research methods and to apply scientific learning that improves their learning method in the long term (Alkan, 2016; Delen & Kesercioğlu, 2012). The acquisition of science process skills is the basic requirement of research that the students need in learning certain concepts of chemistry. In addition, science process skills play an important role for the students in completing certain tasks and solving various problems (Harahap, Manurung, Marbun, & Mihardi, 2016). Hence, problem solving is best done by conducting experiments during which scientific information from different sources is taken into account (Aktamis & Ergin, 2008; Irwanto, Saputro, Rohaeti, & Prodjosantoso, 2018).



JOURNAL
OF BALTIC
SCIENCE
EDUCATION

ISSN 1648-3898 /Print/
ISSN 2538-7138 /Online/

Abstract. *This research explored the level of students' basic and integrated Science Process Skills (SPS) based on their academic majors, gender, and grade levels at the end of a chemistry laboratory course. Convenience sampling was used to select 298 undergraduate students at the Yogyakarta State University, Indonesia. A survey method was used, and the data were collected using the Basic SPS (BSPS) and Integrated SPS (ISPS) Observation Checklist. The results showed that the students' basic and integrated SPS were considered medium and low respectively. Furthermore, there was a significant gap in the students' performance based on their majors, gender and grade levels. Surprisingly, it was found that the perception and social convention that males are stronger than females in science appears not to be the case among students. Moreover, there was a moderate positive and significant correlation between students' basic and integrated SPS. Students with a high basic SPS score had the tendency to obtain a higher integrated SPS score. Therefore, it is concluded that prior to starting lab course activities, lecturers need to determine their students' process skills in order to plan in such a manner that they can assist to raise their students' current basic and integrated SPS.*

Keywords: *academic majors, grade levels, science process skills, undergraduate students.*

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The SPS are the major skills that determine students' comprehension upon certain concepts about science (Abungu, Okere, & Wachanga, 2014), especially chemistry. Generally, these process skills are stratified into two levels; basic and integrated process skills (Aka, Güven, & Aydoğdu, 2010; Arabacioglu & Unver, 2016; Lati, Supasorn, & Promarak, 2012; Padilla, 1990). Basic process skills include observing, inferring, measuring and communicating. Integrated process skills include identifying and controlling variables, investigating, formulating hypotheses, experimenting and interpreting data. The application of science process skills adjusts with students' education level. Basic process skills are an appropriate set of skills to introduce in science learning for students of primary school level, while the integrated process skills are more suitable for higher education level (Aydoğdu, Erkol, & Erten, 2014; Seetee, Coll, Boonprakob, & Dahsah, 2016). However, both basic and integrated process skills are inter-correlated.

In the context of 21st century learning, SPS cannot be separated from the teaching of science. These process skills are regarded as a requirement that enables students to learn and understand science (Ergül et al., 2011; Yakar, 2014). As such, developed SPS has the potential to contribute in a manner that it could have a positive effect on the success of science teaching. A number of previous studies have confirmed the existence of correlation between science process skills and formal reasoning ability (Oloyede, 2012; Padilla & Okey, 1983; Shaibu & Mari, 2003), learning achievement (Aktamis & Ergin, 2008; Delen & Kesercioğlu, 2012; Feyzioğlu, 2009; Osman & Vebrianto, 2013), scientific literacy (Kaya, Bahceci, & Altuk, 2012), creativity (Ozdemir & Dikici, 2017) and scientific attitude (Downing & Filer, 1999; Zeidan & Jayosi, 2015). Through the implementation of science process skills, students are engaged into authentic science teaching that stimulates their curiosity. In another word, efficient science teaching can be done by implementing process skills in a simultaneous way (Aydin, 2013).

In another study, Jeon and Park (2014) analyzed the correlation between scientific communication skills and science process skills, logical thinking skills and academic achievement involving 64 sixth grade elementary school students as the samples. The result of the study indicated certain considerable correlations among the variables. It was also highlighted that students' performance and their logics influence their scientific communication skills, which skills were known to have direct influences on students' achievement. In Turkey, Özgelen (2012) investigated students' scientific process skills within a cognitive domain framework of 306 students from sixth and seventh grades. It was found that enhancement of students' scientific process skills improved students' thinking, reasoning, inquiry, evaluation, problem solving and creativity. Finally, Chabalengula, Mumba and Mbewe (2012) conducted a series of test involving 91 elementary pre-service teachers in order to find out the correlation between students' conceptual comprehension and their performance on their process skills. The result of the study showed a weak positive insignificant correlation. The positive correlation indicates that conceptual comprehension is necessary for the students to be able to do their process skills-related assignments. In other words, these process skills have been known to support students' learning achievement, both inside and outside school.

Previous studies also reported the possible influences of gender (Barahmeh, 2017; Eya, 2016; Gürses, Çetinkaya, Doğar, & Şahin, 2015; Tek, Tuang, Yassin, Baharom, Yahya, & Said, 2012), grade levels (Beaumont-Walters & Soyibo, 2001; Erkol & Ugulu, 2014; Gürses et al., 2015; Tek & Ruthven, 2005) and academic majors (Gürses, Cuya, Güneş, & Doğar, 2014; Lee, 1993) on students' scientific process skills. In Malaysia, Ong, Ramiah, Ruthven, Salleh, Yusuff and Mokhsein (2015) categorized students' achievement based on grade level, involving 220 students of elementary schools. The result of the study showed a significant gap between the scores of fourth and sixth graders in terms of measuring, predicting and inferring skills. Moreover, Barahmeh, Hamad and Barahmeh (2017) also explored the influence of a Fermi question on students' performance in physics learning, involving 85 students in the ninth grade. The result showed a statistically significant gap in students' process skills scores based on their gender in favor of females. Similarly, Zeidan and Jayosi (2015) also found a significant influence between science process skills and students' scientific attitudes based on gender in favor of females.

Jeon and Park (2014) posit science process skills as a key factor in students' academic achievement. Students with high performance are likely competent in applying logical and systematic thinking to complex situations. In line with the statement, Ergül et al. (2011) expressed that students with high performance in science process skills are able to think logically, phrase questions and know the way to answer them, and they are better at solving various problems. Students' science process skills can be improved by involving them in scientific activities, one of which is the optimization of process-oriented laboratory activities. Bolat, Türk, Turna and Altınbaş (2014) believed that laboratory activities offer authentic experience to the students which eventually help them to understand various scientific concepts and enhance their performance level as well. In line with this statement, Myers and Dyer (2006) stated that students who are taught using the investigative laboratory approach tend to have better content knowledge and higher science process skills than those who are taught using the prescriptive laboratory approach.



In the context of science process skills enhancement, laboratory activities and these process skills are inter-related since, both of them are useful in helping the students to understand and apply concepts of chemistry to solve various issues. Seung, Choi and Pestel (2016) emphasized the role of laboratory activities in improving students' understanding of scientific skills to use in expanding their comprehension on chemistry. Science process skills are teachable and it can be facilitated to the students using laboratory activities that are intended to build and strengthen their comprehension upon the concepts of chemistry through scientific research (Coil, Wenderoth, Cunningham, & Dirks, 2010; Taber, 2016). This insight makes sense considering the fact that science process skills are a set of skills used by individuals in comprehending certain scientific knowledge (Mutisya, Rotich, & Rotich, 2013). Scientific knowledge can only be obtained through the implementation of scientific methods that are developed using science process skills. Henceforth, it is understood that the laboratory holds the key to students' performance improvement (Alkan, 2016; Irwanto, Rohaeti, Widjajanti, & Suyanta, 2017b; Karamustafaoğlu, 2011; Seyhan, 2015).

The SPS deal with how individuals seek and process information through scientific investigation. In Turkey, Aktamis and Ergin (2008) have investigated the effect of scientific process skills in improving students' scientific creativity, attitudes towards science and science achievements. The study indicated that scientific process skills successfully improved students' learning achievement and scientific creativity. Similarly, Abungu, Okere and Wachanga (2014) also argue that science process skills have the ability to improve students' performance and scientific skills which influence their chemistry achievement. In addition, Oloyede (2012) also highlighted that students with high process skills tend to be more capable in solving unfamiliar issues. The explanation above proposes that in order to achieve excellent learning output and optimal performance, educators are required to systematically measure and evaluate students' science process skills (Cigrik & Ozkan, 2015). The measurement and evaluation of science process skills are significant with reference to chemistry programs and in chemistry education programs, as society and industry expect that science graduates have high competence in investigating and addressing actual problems using the scientific method and at the same time anticipating the occurrence of ill-structured problems in the future.

Motivation and Objectives

Within the context of chemistry teaching in Indonesia, it is important to integrate SPS into the curriculum of laboratory learning to reduce the frequency of lecturing activities. This approach has been considered effective in developing students' psychomotor competence through various laboratory activities. Hence, to teach certain content and improve students' performance, lecturers need to integrate the training of soft skills into the teaching of hard skills. This approach is also known for its ability to improve students' collaborative and problem solving skills, since students are exposed to daily life issues. Based on aforementioned issues, the objectives of this research were summarized as follows:

- a) To apply the laboratory learning strategy which does not only promote students' mastery on chemistry concept, but also enhances various generic skills needed for problem solving.
- b) To apply certain laboratory teaching methods which are able to assist with improving students' academic performance through the utilization of laboratory experiences.
- c) To map students' performance prior to science programs in order to plan for and promote process skills as a bridge to connect the teaching and research in higher education. It is also expected that when students are assisted to improve their process skills profiles, this could lead to the enhancement of the quality of graduates, as well as enhancing education programs at tertiary level.

Research Focus

In this research, students' science process skill levels were analyzed based on several factors including academic majors, genders and grade levels. The correlation between students' basic and integrated process skills were also explored. Regarding to the literature discussed previously, the following research questions were formulated:

- a) What is the level of the basic process skills and integrated process skills of undergraduate chemistry and chemistry education students in a chemistry laboratory course?
- b) Is there a significant gap in undergraduate students' process skill scores based on their academic majors, gender and grade levels?
- c) What is the relationship between students' basic and integrated process skills?



Research Methodology

Research Background

This research was conducted by means of a survey followed by correlational research analysis. Creswell (2008) explained that correlational research aims at understanding the correlation between two or more research variables. In this research, students' basic and integrated process skills were the dependent variables, while students' academic majors, gender, and grade levels were the independent variables. This survey was executed at the end of the academic year when students had completed all of the experiments, since it was considered necessary to investigate students' SPS acquisition and evaluate the effectiveness of the laboratory method which had been implemented in a semester. The result of this research can be used as a reference for lecturers in improving students' SPS using other laboratory methods which are considered more effective.

Research Sample

In the main research, there were 298 undergraduate chemistry and chemistry education students (age between 18-20 years) at the Yogyakarta State University, Indonesia in the academic year of 2017/2018 who were selected using the convenience sampling technique to participate as the samples (see Table 1). These students consisted of first-year and second-year students enrolled for chemistry as a major or chemistry education. Convenience sampling is one of non-probability sampling methods in which the population of the research is ready and feasible to be accessed by researchers (Fraenkel, Wallen, & Hyun, 2012). In this survey, none of students refused to participate as research sample. Therefore, all 298 cases explored in this study provide valid information.

Table 1. Distribution of samples.

Academic Majors	N	Percentage
Chemistry	152	51.0
Chemistry Education	146	49.0
Total	298	100
Gender		
Male	92	30.9
Female	206	69.1
Total	298	100
Grade Levels		
First-year	148	49.7
Second-year	150	50.3
Total	298	100

Instrument and Procedures

The first step of this research was developing valid and reliable instruments. The researchers preferred constructing new instruments to translating the available test in order to make sure that the tool was relevant with the conditions of the laboratory learning, students' characteristics and the curriculum of chemistry in university level in Indonesia. A literature review on science process skills was done prior to designing the research instrument, from which 9 sub-skills were determined as the indicators that reflect students' basic and integrated process skills (Aka et al., 2010; Arabacioglu & Unver, 2016; Karamustafaoğlu, 2011; Karsli & Şahin, 2009; Özgelen, 2012; Padilla, 1990). In the pilot research, the instruments were validated by 13 senior lecturers before being distributed to 176 randomly-selected students of a chemistry major in Yogyakarta. The instruments employed in this study were Basic and Integrated Process Skills Observation Checklist.



Basic Process Skills Observation Checklist (BPSOC)

A research instrument called BPSOC was developed by the researchers to measure the students' basic process skills. The BPSOC consisted of 8 items including the measurement of students' observing, inferring, measuring and communicating skills which each consisted of 2 items. A rating of 1 to 4 was assigned to each Likert scale statement (4 = highly observed, 3 = observed, 2 = less observed and 1 = unobserved). The highest score indicated advanced skill of the students while conducting their laboratory experiments. The minimum and maximum scores that could be obtained by each student were 8 points and 32 points respectively. The coefficient of Cronbach's alpha reliability test was .74, higher than the minimum requirement of instrument reliability score at .70 (Nunnally & Bernstein, 1994). This result showed that the BPSOC instrument was considered reliable in measuring the students' performance related to basic science process skills. Students' basic process skills were stratified into 3 levels; low (<16 points), medium (16-24 points) and high (>24 points).

Integrated Process Skills Observation Checklist (IPSOC)

In order to measure the students' integrated process skills, the researchers have developed an instrument called IPSOC. The IPSOC consisted of 10 items to measure students' performances in identifying and controlling variables, investigating, formulating hypotheses, experimenting and interpreting data which each consisted of 2 items. In a similar way, a rating of 1 to 4 was assigned to each Likert scale statement for the IPSOC instrument (4 = highly observed, 3 = observed, 2 = less observed and 1 = unobserved). The minimum score was 10, while the maximum score was 40 points. The result of the reliability test showed the Cronbach's alpha coefficient at .88, which indicated that IPSOC was a reliable instrument to measure students' performance. The students' integrated process skills were stratified into 3 levels; low (<20 points), medium (20-30 points) and high (>30 points). Furthermore, both BPSOC and IPSOC were used to observe student activities during the chemistry laboratory course.

Permission to conduct this study was obtained prior to conducting the research from the Head of the Department of Chemistry Education. In a chemistry laboratory course, students are given guidelines to chemical experiments provided by the lecturer. They are then instructed to do the step-by-step procedure in the laboratory. During the data collection, students were instructed to perform laboratory tasks in small groups based on the pre-determined experiment procedure given. After that, they were asked to show their skills in conducting experiments, discussion and solving certain problems. At the end of the experiment, students are required to write laboratory work report. They also had been informed that the results of the observation were not evaluative, as the results will be used for research purposes only. The process of data collection is illustrated in Figure 1.

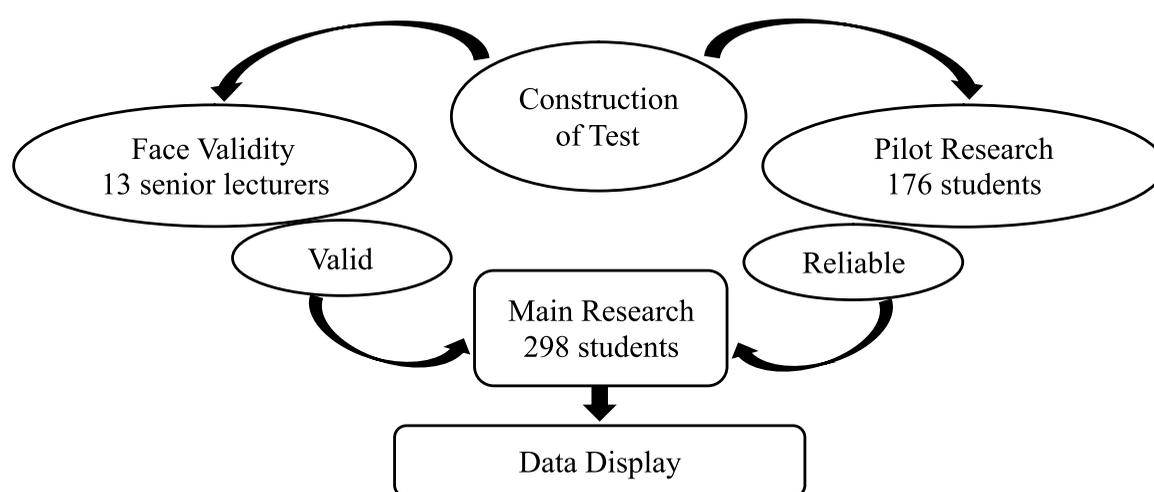


Figure 1. The process of data collection.



Data Analysis

The data analysis was conducted using SPSS version 17 (SPSS Inc., Chicago, IL, USA). Descriptive statistics including the mean, standard deviation, maximum and minimum scores, as well as the percentage of the data were calculated to determine the sample demographics. The t-test was administered to identify any significant average scores obtained by the students based on their majors, gender and grade levels. To measure the significance within the correlation between students' basic and integrated process skills, the Pearson correlation and regression analysis were employed. The level of significance in this research was set at .05.

Research Results

The Level of the Basic and Integrated Process Skills of Undergraduate Chemistry and Chemistry Education Students in a Chemistry Laboratory Course

Students' science process skills levels have been measured using two sets of validated research instruments, namely BPSOC and IPSOC. The result of the data analysis (see Table 2) showed that students' average basic process skills scores were at a medium level ($M=17.20$, $SD=2.881$), whilst their average integrated process skills scores were at a low level ($M=17.44$, $SD=4.360$).

Table 2. The level of students' basic and integrated process skills.

Variables	N	Max	Mean	SD	Percentage	Level
Basic Process Skills	298	32	17.20	2.881	53.75	Medium
Integrated Process Skills	298	40	17.44	4.360	43.60	Low

As presented in Table 3, the students' average score was 34.64 out of 72. This result shows that students' process skills were considered to be at a low level. Their observing and communicating skills were the highest and the lowest skills in basic process skills category, respectively. With reference to their integrated process skills, interpreting data scored the highest, while identifying and controlling variable skills were the lowest ones. It was also noted that the percentage of the students' basic process skills was higher than their integrated process skills.

Table 3. Descriptive statistics of students' science process skills.

Science Process Skills	No. of Item	Mean	SD	Percentage
Basic Process Skills				
Observing	2	4.62	1.019	57.76
Inferring	2	4.13	1.065	51.59
Measuring	2	4.42	.989	55.24
Communicating	2	4.03	1.079	50.42
Integrated Process Skills				
Identifying and Controlling Variables	2	3.16	1.116	39.47
Investigating	2	3.25	1.255	40.65
Formulating Hypotheses	2	3.42	.996	42.79
Experimenting	2	3.70	1.020	46.22
Interpreting Data	2	3.91	1.119	48.91
Total	18	34.64	6.277	48.12



Significant Gap in Students' Science Process Skills Based on Academic Majors

The measurement showed no significant gap in the average science process skills scores between students from the chemistry major and those from the chemistry education major in term of basic process skills ($p > .05$). In addition, in terms of integrated and overall process skills, a significant gap has been found in the average scores of students from the chemistry major and from the chemistry education major in terms of integrated and overall process skills ($p < .05$). Generally (see Table 4), the average score of students from the chemistry major ($M=36.06$, $SD=6.814$) was higher than the ones from the chemistry education major ($M=33.17$, $SD=5.297$), even though the gap between those two groups was only 2.89 points different.

Table 4. Gap in students' science process skills scores based on academic majors.

Variables		N	Mean	SD	p
Basic Process Skills	Chemistry	152	17.35	3.071	.369
	Chemistry Education	146	17.05	2.671	
Integrated Process Skills	Chemistry	152	18.71	4.640	.001
	Chemistry Education	146	16.12	3.616	
Overall Process Skills	Chemistry	152	36.06	6.814	.001
	Chemistry Education	146	33.17	5.297	

Significant Gap in Students' Science Process Skills Based on Gender

A significant gap was found in average science process skills scores between male and female students in terms of basic, integrated and overall process skills ($p < .05$). Overall (see Table 5), female students ($M=36.08$, $SD=6.111$) obtained average score 4.65 points higher than male ($M=31.43$, $SD=5.419$).

Table 5. Gap in students' science process skills scores based on gender.

Variables		N	Mean	SD	p
Basic Process Skills	Male	92	15.72	2.974	.001
	Female	206	17.86	2.583	
Integrated Process Skills	Male	92	15.72	3.417	.001
	Female	206	18.21	4.519	
Overall Process Skills	Male	92	31.43	5.419	.001
	Female	206	36.08	6.111	

Significant Gap in Students' Science Process Skills Based on Grade Levels

With reference to, "Is there a significant gap in students' science process skills based on their grade levels?"; a significant gap has been found between the average process skills score obtained by first-year and the one achieved by second-year in terms of basic, integrated and overall process skills ($p < .05$). Overall (see Table 6), the second-years ($M=36.32$, $SD=6.550$) obtained average score 3.37 points higher than the first-year students ($M=32.95$, $SD=5.508$).



Table 6. Gap in students' science process skills scores based on grade levels.

Variables		N	Mean	SD	p
Basic Process Skills	First-year	148	16.29	2.853	.001
	Second-year	150	18.10	2.623	
Integrated Process Skills	First-year	148	16.66	3.595	.002
	Second-year	150	18.22	4.891	
Overall Process Skills	First-year	148	32.95	5.508	.001
	Second-year	150	36.32	6.550	

The Relationship between Students' Basic and Integrated Process Skills

Based on the result of the correlation test administered in this research, a positive and significant correlation between the students' basic and integrated process skills has been confirmed ($r=.481, p<.05$). According to the categorization of correlation coefficient proposed by Cohen (1988), the coefficient found in this research indicated a moderate positive association. It was found that students with higher basic process skills scores tend to have better integrated process skills scores. Thus, it can be expressed that an improvement in students' basic process skills scores would likely to improve their integrated process skills scores. On the other hand, the analysis of linear regression resulted to $R^2=.231, F(1, 296)=89.063, p=.001$. The number indicates that the linear regression explains as much as 23.10% of the variances in the data.

Table 7. Pearson's correlation coefficient for science process skills.

		Integrated Process Skills
Basic Process Skills	Pearson Correlation	.481**
	Sig. (2-tailed)	.001
	N	298

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

Discussion

The aims of this research were to ascertain the level of undergraduate students' science process skills based on their academic majors, gender and grade levels and to investigate the relationship between students' basic and integrated process skills. These students were enrolled for a chemistry laboratory course. The results of the two instruments revealed that generally, students' average basic process skills score was included in the medium level (53.75%), while their average integrated process skills score was considered low (43.60%). The observation results show that students' low performance occurred due to the fact that they merely performed the experiment to finish certain procedure. It was also found that lecturers did not teach the students strategies to assist in developing good process skills (Anwar, Senam, & Laksono, 2018; Irwanto, Rohaeti, & Prodjosantoso, 2018). Consequently, students failed to perform the hands-on activities well. In addition, lectures were unready to apply effective laboratory teaching methods to enhance students' performance and they did not yet relate the concepts of chemistry, laboratory works with daily life, leading to students' low process skills (Feyzioğlu, 2009). Those results indicate that students' performance needs to be improved.

Several previous studies also obtained similar results (e.g., Aydoğdu, 2015; Irwanto et al., 2017; Lati et al., 2012; Özgelen, 2012; Segumpan, 2001), showing that students had poor level of science process skills. In another study, Tilakaratne and Ekanayake (2017) found that students' basic process skills were in the medium level. Meanwhile, Öztürk, Tezel and Acat (2010) also reported that students had low performance in inferring, controlling variables and experimenting skills. It was suggested that their low achievement levels could be enhanced through the implementation of discovery learning activities and the optimization of hands-on activities in laboratory (Foulds & Rowe, 1996; Karamustafaoğlu, 2011). The result of this research is supported by Koksal and Berberoglu (2014) who believed that science process skills are improvable through the implementation of the guided-inquiry approach.



Furthermore, the researchers found that the percentage of students' basic process skills score was higher than their integrated process skills score, as stated by Akinbobola and Afolabi (2010).

It has been confirmed in this research that students' identifying and controlling variables skill was the lowest (39.47%), while their observing skill showed the highest score (56.76%). Seen from students' written lab report, most students experienced difficulties in determining, identifying and creating the operational definition of the variables used in an experiment. Even more, the majority of the students (86.90%) admitted that they had found difficulties in controlling or giving certain treatment to the variables in experiments they conducted. On the other hand, half of the students (52.00%) employed their five senses in conducting various observations, even though some students showed passive behaviors. Similarly, Aziz and Zain (2010) concluded that the observing skill was considered easier than other skills. In addition, Karamustafaoğlu (2011) and Seetee et al. (2016) also reported identifying and controlling variables skill was the integrated process skills that obtained the lowest scores. The results of this study concur with those of Karamustafaoğlu (2011) and Seetee et al. (2016) as it appears that the students in our study regarded those skills the hardest ones to master too, as the results from other studies mentioned, also showed that integrated process skills are more complex than the basic process skills. Özgelen (2012) argued that integrated process skills require more advanced basic comprehension than the basic process skills. Basic process skills are also seen as the prerequisite of the integrated process skills. Hereafter, integrated process skills can be used to solve more complex issues. In line with this insight, Akinbobola and Afolabi (2010), Aydoğdu (2015) and Segumpan (2001) also pointed that students' integrated process skills scores were lower than their basic process skills scores. The poor integrated process skills might be influenced by the fact that it demands more advanced scientific mind, making it more difficult to master (Segumpan, 2001).

Regarding the result pertaining to academic majors, there was no significant gap found between the average process skills scores of the students from the chemistry major and from the chemistry education major in term of the basic process skills. However, a significant gap was found between the average scores of students from the chemistry major and chemistry education major in term of integrated process skills. Students' overall process skills scores contained a significant gap when the average scores are compared based on the students' majors. Generally, students from the chemistry major obtained the highest and the lowest scores in observation skill and identifying and controlling variable skill, respectively. Meanwhile, students from the chemistry education major have the highest and the lowest scores on the measuring skill and identifying and controlling variables, respectively. It can be thus seen that the identifying and controlling variable skill is considered as the toughest skill to master. Students from chemistry major also tend to have high average scores in all of the sub-skills, except the measuring skill. However, it cannot be stated that all pre-service chemistry teachers have poor skills. In Indonesia, students majoring in chemistry are oriented in such ways to become future chemists, while students majoring in chemistry education are prepared to become chemistry teachers in both secondary schools and high schools. Consequently, students from the chemistry major tend to have higher interest and better skills in chemistry that support their future career as chemists.

In line with Gürses et al. (2014), chemistry education students showed significantly higher average process skills scores compared to mathematics and elementary education students. The Anova test also showed a significant gap in students' average scores between groups ($p < .05$). In a study conducted by Silay and Çelik (2013) on the identification of science process skills levels of pre-service teachers of physics, science, chemistry and biology, it was found that the students' performance was at a medium level. They also found no significant gaps in the students' score according to their branches. In Turkey, Sezek, Zorlu and Zorlu (2015) also found a similar result. On the contrary, Nuzulia, Adlim and Nurmaliah (2017) did not find any gap in the integrated process skills scores obtained by students majoring biology, chemistry and physics education. However, we assume that academic majors are one of the factors affecting the students' science process skills.

When the data were analyzed based on gender, a significant gap was found in terms of basic, integrated and overall process skills. Overall, female students obtained the highest score and the lowest one in the observing skill and identifying and controlling variables skill, respectively, whereas, male students obtained the highest score and the lowest score in the observing skill and investigating skill, respectively. This result indicates that female students have a higher average score in all sub-skills. However, this finding does not conform the ones found by Beaumont-Walters and Soyibo (2001) and Obialor, Osuafor and Nnadi (2017) which state that no significant difference existed in students' score seen from the gender aspect, despite the fact that male students tend to obtain higher scores than female students. The different result found in this study might be influenced by the rapid development of women's emancipation (Jatiningsih, 2017). The result of this study also indicates that the stereotype and social convention



that "males are stronger than females" science wise are crumbling. In addition, female students showed adequate capability in creating written lab report, orally communicating and interpreting the report at the end of experiment.

In the last decades, the influence of gender in students' process skills have attracted some researchers to explore this issue. Aydinli et al. (2011) and Dönmez and Azizoğlu (2010) also found a similar result to this research. In a separated study, Guevara (2015) employed an innovative approach in the teaching of general biology to enhance these skills and to find out if gender affected students' performance. In the research, it is found that female students were likely to obtain higher process skills scores than males. In other studies, Seetee et al. (2016) and Zorlu, Zorlu and Sezek (2013) also reported a parallel research result. This phenomena might occur, because female students had stronger commitment in learning the chemistry through experiment activities compared to males, as reported by Dhindsa and Chung (2003). Furthermore, Chan and Norlizah (2017) and Majere, Role and Makewa (2012) also believe that females tend to have a more positive attitude, perception, and motivation than males.

In this research, a significant gap was found in the process skills scores obtained by first-year and second-year students in terms of basic, integrated and overall process skills. The first-year students obtained the highest and the lowest scores in the observing skill and investigating skill respectively, while the second-year ones obtained the highest and the lowest one in the observing skill and identifying and controlling variables skill, respectively. Similarly, Gürses et al. (2015) and Silay and Çelik (2013) also found a similar result during their research. Based on the data analysis conducted in this research, second-year students had better science process skills mastery than the first-year students. This phenomenon occurred, because the second-year students had previously attended a number of laboratory courses that they had richer experience and better skills, even though all of them have not yet shown satisfying performance. This finding is contradictory to Farsakoğlu, Şahin and Karsli (2012) whose research result showed that there was no significant difference that existed in pre-service science teachers' performance based on the grade levels. Even more, they found that there was no direct relationship between grade levels and science process skills.

In line with the current result, Yakar (2014) also claimed better improvements in the process skills scores of third-year and fourth-year compared to the second-year pre-service teachers. Moreover, Aydinli et al. (2011) noticed an obvious gap in students' integrated process skills related to their grade levels ($p < .05$), in which students in the higher grade levels obtained higher process skills scores. Furthermore, Kalemkuş, Bayraktar and Kalemkuş (2016) also reported that eighth grade students achieved a greater percentage of success than the fifth graders. In this research, second-year students obtained relatively higher scores which can be related to their well-developing cognitive skills. Lee (1993) found that students' cognitive development and science process skills have a positive and significant correlation with their attitude towards science.

A positive and significant correlation has been confirmed between students' basic and integrated science process skills scores. This result shows that students with higher basic science process skills scores tend to have better integrated science process skills mastery. A study conducted by Rabacal (2016) also confirmed a positive correlation between students' basic and their integrated science process skills ($r = .58$; $p = .001$) and it is suggested that university students do more experiments to enhance their performance. It is also proposed by Farsakoğlu et al. (2012) that better performance can be obtained through meaningful experiences from hands-on practices or experiences. A similar view was shared by Roth and Roychoudhury (1993), stating that higher-order process skills seem to improve as students experience more non-traditional laboratory activities that give them more independence in trying out their experiments in an authentic classroom.

The finding of this research implies that educational programs need to take serious heed regarding the design of certain learning environments that promote student scientific experimentation tasks, as this has the potential to eventually improve their soft skills. Lecturers should thus not merely transfer the concepts of chemistry through the traditional lecturing method. As the implication, imbalance mastery of hard skills and soft skills trigger failures in applying the knowledge into practice when confronted with new situations. Hence, it is crucial that lecturers develop students' soft skills during the lectures on hard skills as soft skills are considered important in supporting students to develop their scientific concepts, which cannot be built only through academic knowledge. As emphasized by Çoban (2013), Ergül et al. (2011) and Ogan-Bekiroğlu and Arslan (2014), a learning environment that focuses on hands-on practices and experiments promotes students' scientific process skills in an improved way compared to traditional lecturing. Based on the findings, it is evident that lecturers should focus more on enhancing these skills.

Regarding the result of this research, it is suggested that lecturers provide intensive directions for the students and help them to explore hands-on experiments in the laboratory to try to enhance their comprehension of certain material. The implementation of experimental activities in the science laboratory provide students with



problems to solve instead of merely requiring the students to memorize science concepts (Gezer, 2015). In line with this statement, Myers and Dyer (2006) also emphasized that students' comprehension upon the science concepts influences their process skills. More advanced research on this field are still needed, especially the ones that aim at evaluating the influence of experiment-based teaching on students' basic, integrated and overall process skills seen from students' academic majors, gender and grade levels.

Conclusions and Recommendations

The results suggest that the average basic process skills score of undergraduate students is at a medium level, while their average integrated process skills score is considered low. Overall, students had poor science process skills. This research has also found a significant gap between students' achievement seen from their majors, in which it is found that students from chemistry major have slightly higher scores than those from chemistry education major. In addition, a significant gap has been found in students' performance scores based on their gender, where female students have better scores than males. Equally important, it appears that the stereotype and social convention that males are stronger than females cannot be generalized. According to their grade levels, first-year and second-year students showed a significant gap, in which second-year students' process skills scores are higher than the ones obtained by first-year students. Finally, even at a moderate level, a positive and significant correlation has been found between students' basic and their integrated process skills scores.

It is suggested that lecturers determine their students' process skills in order to plan in such a manner that they can assist to raise their students' current basic and integrated SPS by designing science lab activities or methods to the desired level that they view as satisfactory. In other words, lecturers need to implement effective teaching strategies that promote students' science process skills in chemistry learning. These strategies include inquiry-based laboratory projects, problem-solving, project-based learning, and other scientific related hands-on instruction. Consequently, students need to be given more challenging tasks to solve various complex problems in the form of research-based activities. With reference to further research, researchers are encouraged to expand this research by adding more participants from different learning environment and scientific backgrounds.

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Received: March 20, 2018

Accepted: September 02, 2018

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