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Research Article

The correlation between science process skills and biology cognitive learning outcome of senior high school students

Silfia Ilma [a,b,1,*], Mimien Henie Irawati Al-Muhdhar [c,2], Fatchur Rohman [c,3], Murni Saptasari [c,4]

[a] Postgraduate Doctoral Student of Biology Education, Department of Biology, Faculty of Mathematics and Sciences, Universitas Negeri Malang, Jl. Semarang 5 Malang, East Java 65145, Indonesia

[b] Department of Biology Education, Faculty of Teacher Training and Education, Universitas Borneo Tarakan, Jl. Amal Lama No. 1 Tarakan, North Kalimantan 77123, Indonesia

[c] Department of Biology, Faculty of Mathematics and Sciences, Universitas Negeri Malang, Jl. Semarang 5 Malang, East Java 65145, Indonesia

[1] silfiailma@borneo.ac.id*; [2] mimien.henie.fmipa@um.ac.id; [3] fatchur.rohman.fmipa@um.ac.id; [4] murni.sapta.fmipa@um.ac.id

* Corresponding author

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ABSTRACT

Science Process Skills (SPS) are the essential abilities which need to be mastered in learning biology to strengthen students' learning outcomes. The aim of this study was to analyze the relationship between SPS and biology Cognitive Learning Outcome (CLO) of senior high school students. The sample was 100 tenth graders in Malang. The correlational study used two test types as the instrument (i.e. essay and multiple choice). The essay instrument consisted of 10 items which were developed from SPS aspects (basic and integrated skills). Meanwhile, the biology CLO was measured using multiple choice test which consisted of 30 items. The collected data were analyzed using simple linear regression analysis. The results showed that the highest students' SPS aspect was observing (78.84%), while the lowest was predicting aspect (27.30%). In addition, the highest achievement of students' biology CLO was C1 (94.23%), while the lowest was C6 (33.46%). The regression analysis showed that there was a significant correlation between students' SPS and biology CLO, where the equation was Y = 27.988 + 0.311X. Therefore, it is crucial to consider SPS to be integrated into a learning activity by using various learning models that empowering these skills to improve students' biology CLO.

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INTRODUCTION

Learning the 21st-century emphasizes students' scientific thinking (Osborne, 2013; Turiman, Omar, Daud, & Osman, 2012). Scientific thinking is the process of thinking to know something internally (Çakir & Sarikaya, 2010; Kagee, Allie, & Lesch, 2010; Kuhn, 2010; Stevens & Witkow, 2014). Scientific thinking is obtained

through inductive and deductive reasoning to find answers through the exploration of factual scientific inquiry, problem formulation, hypotheses, design, evaluation of evidence, hypothesis testing by experimentation, and conclusions (Thitima & Sumalee, 2012). The ability to think scientifically can be considered as part of critical thinking through claims and arguments about people's behavior from a scientific point of view. Thus, scientific thinking is a form of logical reasoning in the scientific paradigm (Kagee et al., 2010; Stevens & Witkow, 2014). The intended scientific paradigm is that science must be collaborative, complex, and scientific (Corrigan, 2012). Koerber, Mayer, Osterhaus, Schwippert, and Sodian (2015) argue that scientific thinking can be developed through activities such as hypothesis testing, systematic experimentation, interpretation of data related to hypotheses, and a more general understanding of the nature of science. The ability to think scientifically is used to change the paradigm of learning from teacher-centered to student-centered learning, from learning that emphasizes content to process, textual approach to contextual and scientific approaches, transfer of knowledge to problem-solving (Suciati, Ali, Imaningtyas, Anggraini, & Dermawan, 2018). Learning that emphasizes the ideal process can empower students' Science Process Skills (SPS).

SPS are the basic skills in thinking and conducting investigations (Çakir & Sarikaya, 2010; Hodosyová, Útla, Vnuková, & Lapitková, 2015; Mutlu & Temiz, 2013; Turiman et al., 2012). Science process skills are also thinking skills that can be used to obtain information (Handayani, Adisyahputra, & Indrayanti, 2018; Karamustafaoğlu, 2011; Supriyatman & Sukarno, 2014). Sahyar and Nst (2017) describe SPS as active actions such as making observations, identifying problems and predicting what students can develop through exercises in learning science, in learning science students are challenged to strike a balance between science concepts and process skills. Gillies and Nichols (2015) added SPS is able to improve scientific thinking skills and understanding of the material. According to Elmas, Bodner, Aydogdu, and Saban (2018) SPS consists of basic and integrated skills. Basic process skills provide the basis for learning integrated (more complex) skills. Basic process skills consist of observing, guessing, measuring, communicating, classifying, and predicting. Integrated process skills include controlling variables, determining operationally, formulating hypotheses, interpreting data, conducting experiments and formulating models (Elmas et al., 2018). SPS are not only used in problem-solving and knowledge development, but are also involved in scientific reasoning, critical thinking and understanding students' concepts of science (Candrasekaran, 2014; Gillies & Nichols, 2015). Abungu, Okere, and Wachanga (2014) further explained that SPS are used to help students gain an understanding of the material that is more long-term memory so that it is expected to be able to solve all forms of daily life problems, especially in the face of global challenges.

Recognizing the importance of this SPS, it is necessary to explore how its application in learning, especially in Indonesia. Some study shows that SPS has been applied in various fields of science subjects, such as biology (Handayani et al., 2018; Lepiyanto, 2014; Suryaningsih, 2017; Wulandari, Masjhudi, & Balqis, 2014), physics (Irwanto, Rohaeti, Widjajanti, & Suyanta, 2017; Nirwana, Nyeneng, & Maharta, 2014; Siswono, 2017; Syafriyansyah, Suyanto, & Nyeneng, 2013), and chemistry (Siska, Kurnia, & Sunarya, 2013). Some researchers mentioned that this SPS can be accommodated when students learn to use inquiry learning (Lati, Supasorn, & Promarak, 2012; Ramdan & Hamidah, 2015; Sahyar & Nst, 2017; Şimşek & Kabapinar, 2010), hands-on learning (Cigrik & Ozkan, 2015; Suryaningsih, 2017; Wulandari et al., 2014), problem-based learning (Sagala, Rahmatsyah, & Simanjuntak, 2017; Tatar & Oktay, 2011; Wahyuni, Indrawati, Sudarti, & Suana, 2017), and project-based learning (Fajriyanti, Ernawati, & Sujatmika, 2018). There are some studies also stated that SPS can be accommodated through media that is applied in the learning process (Pratono, Sumarti, & Wijayati, 2018; Solé-Llussà, Aguilar, & Ibáñez, 2019; Vebrianto & Osman, 2011).

However, it is also very important to see how the learning objectives are achieved when students already have the science process skills. The achievement of learning objectives, one of which can be measured by students' cognitive learning outcomes (Anderson & Krathwohl, 2001). Cognitive Learning Outcomes (CLO) indicate the level of students' concept understanding (Anderson & Krathwohl, 2001; Sinatra & Mason, 2013). Concept understanding is a learning outcome consisting of remembering, understanding, applying, analyzing, evaluating, and creating (Anderson & Krathwohl, 2001). The students' cognitive skill is a fundamental requirement for students in deal with challenges in everyday life (Osborne, 2013; Wang, Wu, Kinshuk, Chen, & Spector, 2013). Several studies related to the correlation between students' SPS and CLO have been conducted in physics learning (Nirwana et al., 2014; Santiani, 2014; Sinuraya, Panggabean, & Wahyuni, 2019; Siswono, 2017; Syafriyansyah et al., 2013). Sinuraya et al. (2019) claim that students' CLO has been influenced by students' SPS, on the other hand, Santiani (2014) argue that there is a low correlation between students' SPS and CLO. Furthermore, it is also necessary to examine how the relationship between students' SPS and biology CLO, because the research is still limited in empowering students' SPS in biology learning with various learning strategies (Hayati, Bintari, & Sukaesih, 2018; Suryaningsih, 2017; Wahyuni et al., 2017; Wulandari et al., 2014).

Therefore, this study focuses on finding the correlation between students' SPS and students' understanding of biology concepts, more specifically is biology CLO. Biology is the study of life which does not only look at one side of living things but more on the complexity of science (Zeyer, 2018). Consequently, understanding the concept of biology is very important for students to have as a provision to solve the problem in daily life. By acknowledging the relationship between students' SPS and biology CLO, it is assumed that the research finding can be used as a recommendation in improving the biology learning process in Indonesia.

METHOD

The correlational study used 100 tenth graders in Malang as a research sample. The correlational study used two test types as the instrument, namely essay and multiple choice. The essay instrument consisted of 10 items that were developed from SPS aspects (Table 1). SPS aspects include basic and integrated skills (Elmas et al., 2018). The basic skills consist of 1) observing, which uses the senses to gather information about an object or event; 2) predicting, namely giving allegations about an object or event based on data or information collected previously; 3) measuring, namely using standard or nonstandard measurements or estimates to describe the dimensions of an object or event; 4) communicating, using words or graphic symbols to describe an action, object or event; 5) classifying, i.e. classifying events into categories based on criteria; and 6) predicting, states future results based on patterns of evidence. While the integrated skill consists of 1) controlling variables – identify variables that can influence the results of experiments, maintaining the most constant while manipulating independent variables; 2) determine operationally – how to measure a variable in an experiment; 3) formulate a hypothesis – states the expected results of an experiment; 4) interpreting the data – organizing the data and drawing conclusions from it; 5) conducting experiments – including asking the right questions, stating hypotheses, identifying and controlling variables, defining these variables operationally, designing experiments, conducting experiments, and interpreting the results of experiments; and 6) formulating a model – creating a mental or physical model of a process or event.

Table 1. The aspect of students' SPS

No.	The aspects of students' SPS	Description (skills)
1	Observing	Basic
2	Inference	Basic
3	Classifying	Basic
4	Predicting	Basic
5	Communicating	Basic
6	Controlling variables	Integrated
7	Formulate a hypothesis	Integrated
8	Determine operationally	Integrated
9	Formulating a model	Integrated

Meanwhile, the biology CLO was measured using a multiple-choice test which consisted of 30 items. The test was developed using the level of the cognitive domain including 1) remembering, is very important for meaningful learning, 2) understanding, students are said to have understood when they were able to construct meaning from instructional messages, including verbal, written, and communicative graphics, 3) applying, closely related to procedural knowledge, applying consists of running and implementing, 4) analyzing, involves breaking up the material into interconnected parts and forming a whole structure, 5) evaluating, consists of checking and criticizing, and 6) creating, consists of formulating, planning and producing (Anderson & Krathwohl, 2001). Both instruments, essay and multiple-choice, then be validated by the experts (teacher and material expert). The data collected were analyzed using percentage calculation for each aspect of students' SPS and biology CLO. The percentage result then was assessed based on category which formulated by Haviz, Karomah, Delfita, Umar, and Maris (2018), namely: excellent (86-100), very good (76-85), good (60-75), fair (55-59), poor (55-59), and very poor (≤54). To find out the correlation between students' SPS and biology CLO, the data were analyzed using simple linear regression analysis.

RESULTS AND DISCUSSION

The result of students' SPS is shown in Table 2. Based on the result it is known that students have the highest score in the aspect of observing skill with a percentage of 78.84% while the lowest score is predicting skill (27.30%). Students are also still weak in the aspects of classifying, formulating models, communicating, formulating hypotheses, inference, and determine operationally. The students' SPS is basic learning in thinking

and conducting investigations in science learning (Karamustafaoğlu, 2011; Mutlu & Temiz, 2013). The low of students' skills in some aspect of SPS can be affected by the habit of learning that is carried out both inside and outside the classroom (Çimer, 2012). This is also shown from students' answers when they are asked to make a graph of the data presented in the problem. Students are not able to make proper graphics, this is because they do not have good communication skills. In another aspect, the student can't formulate a model. Students are asked to formulate a model of the germination process, but unfortunately, they provide answers that tend to lead to explain the factors that affect germination without clear explanation (Figure 1). This shows that students do not understand the concept of germination. This can happen because students only memorize concepts, without ever seeing directly or practicing. Some studies show that hands-on activity has a great contribution to empower the students' science process skills (Cigrik & Ozkan, 2015; Lepiyanto, 2014; Siska et al., 2013; Suryaningsih, 2017; Wulandari et al., 2014). Prasasti and Listiani (2018) added that practicum-based learning can improve students' science process skills, because students determine concepts through systematic activities such as formulating problems, making hypotheses, designing experiments, implementing designs they make in the lab, and trying to be able to communicate the results of research as a solution to the problem found.

Table 2. The result of students' SPS test

No.	The aspects of students' SPS	Percentage (%)	Category
1	Observing	78.84	Very good
2	Inference	44.61	Very poor
3	Classifying	33.07	Very poor
4	Predicting	27.30	Very poor
5	Communicate	42.69	Very poor
6	Controlling variables	64.61	Good
7	Formulate a hypothesis	44.23	Very poor
8	Determine operationally	48.07	Very poor
9	Formulating a model	33.46	Very poor

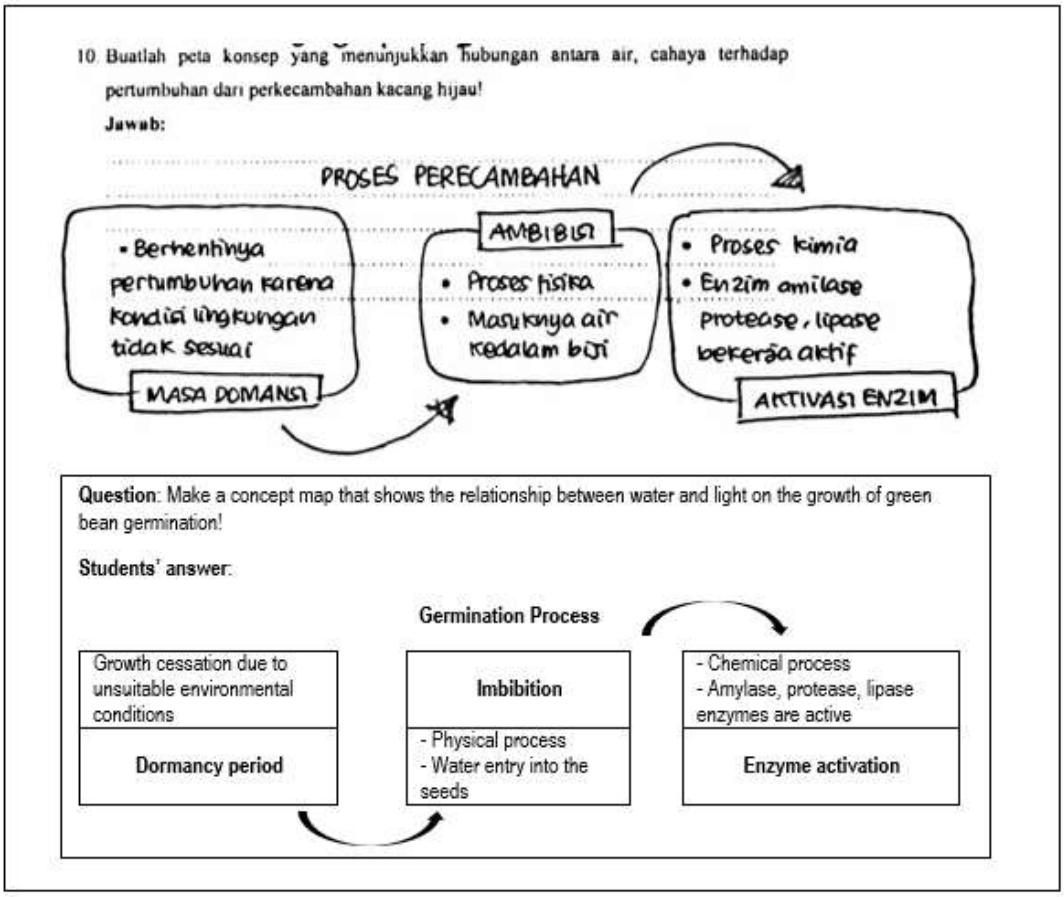

Figure 1. The example of students' answer

Another lower aspect is formulating hypotheses skills. One of the causes of the weakness of students in formulating hypotheses is learning that does not pay attention to the scientific process and only prioritizes concepts. Gultepe (2016)

states that learning science must involve the content and components of the science process. The content and components of the scientific process are an inseparable unity. In formulating a hypothesis closely related to the ability of hypothetical-deductive thinking, namely the ability to think related to finding alternative explanations or hypotheses in responding to a problem and reviewing the data of each hypothesis to make the right decision (Shahali, Halim, Treagust, Won, & Chandrasegaran, 2017; Wahyuni et al., 2017). In addition, the use of learning models also influences on students' SPS. Some researchers stated that SPS can be accommodate using inquiry (Koksal & Berberoglu, 2014; Lati et al., 2012; Rahmasiwi, Santosari, & Sari, 2015; Ramdan & Hamidah, 2015; Şimşek & Kabapinar, 2010).

According to Gillies and Nichols (2015) science process skills are not only used in problem-solving and knowledge development, but are also involved in scientific reasoning, critical thinking and understanding students' concepts of science. Asrizal, Amran, Ananda, Festiyed, and Sumarmin (2018) added that teaching materials which integrate science process skills can improve scientific literacy and student learning outcomes. Science process skills provide opportunities for students to further empower the thought process. This is because the science process skills actively involve students in conducting scientific-based learning activities. Science process skills have a major influence on the development of higher mental processes of order critical thinking and decision making. Lati et al. (2012) report that providing training in science process skills can improve the learning achievement of students. Abungu et al. (2014) further explained that science process skills are used to help students gain an understanding of the material that is more long-term memory so that it is expected to be able to solve all forms of daily life problems, especially in the face of global challenges. The importance of science process skills for students in learning, making a learning process must be well designed so that it can be accepted and understood by students.

Table 3 present the result of students' biology CLO. The result shows that the best score is in remembering (94.23 %,) which is at the lowest level of the cognitive domain (C1). Meanwhile the lowest percentage is at the C6 level (creating) namely 33.46%. In the other level of cognitive domains (understanding, applying, analyzing, and evaluating) are categorized as a good category. This is caused by the biology learning process which still emphasizes memorization. The utilization of learning methods that are still conventional cannot support students to understand biological concepts. Understanding concepts, more specifically CLO, is one of the initial knowledge that students must possess (Sinatra & Mason, 2013). The learning model used will certainly influence students' understanding. This is reinforced by the results of research which state that the use of group investigative learning models and inquiry can improve students' understanding of concepts (Andi & Umamah, 2018; Johanis, 2015; Sahyar & Nst, 2017; Şimşek & Kabapinar, 2010). Tendrita, Safilu, and Parakkasi (2016) added that students' understanding of concepts can use the SQ3R (survey, question, read, review, review) strategy because this research is only to avoid memorization. Understanding of concepts is important for integrating nature and technology into real life in society. Lack of understanding of concepts will result in suboptimal learning outcomes and decreased competitiveness of students to achieve the progress of the times. Students' understanding of a concept will make it easier for students to understand concepts and their learning outcomes will increase (Armi & Noviyanti, 2014; Lestari, Wardani, & Sumarti, 2018).

Table 3. The result of students' biology CLO test

No.	The level of the cognitive domain	Percentage (%)	Category
1	Remembering	94.23	Excellent
2	Understanding	72.11	Good
3	Applying	70.19	Good
4	Analyzing	62.30	Good
5	Evaluating	74.35	Good
6	Creating	33.46	Very poor

The simple linear regression analysis result is presented in Table 4. The regression analysis showed that there was a significant correlation between students' SPS and biology CLO, where the equation was Y = 27.988 + 0.311X, Y is the student's SPS and X is the students' biology CLO. The regression coefficient is 0.311 which means that each addition of 1 SPS point will increase the understanding of the biological concept by 0.311. The significance value is 0.002 (<0.05), so it can be concluded that there is a significant correlation between students' SPS and biology CLO.

Table 4. Summary of simple linear regression analysis

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	27.988	5.829		4.801	.000
	Understanding of Biological Concept	.311	.096	.310	3.229	.002

The process of science learning can be interpreted as scientific activities carried out by students through science learning, to achieve a balance of concepts and skills in the field of science (Sahyar & Nst, 2017). The students' SPS has a significant correlation with students' biology CLO. This is supported by some research which finds that science process skills provides positive interaction with student's concept understanding (Handayani et al., 2018; Nirwana et al., 2014; Siswono, 2017; Syafriyansyah et al., 2013; Wahyuni et al., 2017). The SPS aspect is related to students' understanding of concepts (Gultepe, 2016). This is related to aspects in SPS that support students to do scientific work and mastery of concepts (Elmas et al., 2018). In the aspect of observation, students support to use objects in phenomena that occur. Ongoing observation activities will discuss students to discuss a concept (Nugraha, Utari, Saepuzaman, Solihat, & Kirana, 2019).

The students' SPS contributes to increasing students' understanding through learning activities that promote science such as practical activities (Cigrik & Ozkan, 2015; Sukarno, Permanasari, & Hamidah, 2013; Suryaningsih, 2017). Shahali et al. (2017) stated that students who did not develop SPS were feared that they could not incorporate concepts that emerged into the knowledge system, collect relevant verifications to answer questions or ask questions scientifically. Therefore, SPS students can be facilitated through learning activities that involve students in working activities. The right learning strategy can improve students' SPS and students' understanding of concepts (Ekawati, Iswari, & Lisdiana, 2018). Hernawati, Amin, Irawati, Indriwati, and Omar (2018) describe learning strategies is important for students' science process skills, basic and integrated skills. Supriyatman and Sukarno (2014) added that the inquiry strategy was able to improve students' SPS and concept understanding because students were given the freedom to make observations, experiment planning, and the concept of implementation.

The students' SPS convinces students to better understand the whole concept. This can be obtained through science activities that can lead students to fully understand biological concepts (Güler & Şahin, 2019). Based on the research finding, the students' SPS needs to be developed in learning activities by using various learning models which can accommodate these skills. Thus it can help the teacher to enhance the students' understanding of biological concepts.

CONCLUSION

The research finds that the highest students' SPS aspect was observing (78.84%), while the lowest was predicting (27.30%). Besides, the highest achievement of students' biology CLO was C1 (94.23%), while the lowest was C6 (33.46%). The regression analysis showed that there was a significant correlation between students' SPS and biology CLO, where the equation was Y = 27.988 + 0.311X. Therefore, it is crucial to consider SPS to be integrated into a learning activity by using various learning models that empowering these skills to improve students' understanding of biological concepts.

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