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Analysis of Science Process Skills Based on Programme for International Student Assessment Test and Observation Instruments of Senior High Schools

E. Agustiani[1*], N. S. Aminah[1], R. Suryana[2]

[1]Master Program of Physics Education, Faculty of Teacher Training and Education, Universitas Sebelas Maret, Indonesia
[2]Department of Physics, Faculty of Mathematics and Natural Sciences, Universitas Sebelas Maret, Indonesia

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Abstract

This research aims to figure out the students' Science Process Skills (SPS) using problem tests of Programme for International Assessment (PISA) and observation instruments in Senior High School at Bojonegoro Regency. This work is descriptive research. As research subjects, 100 students in the eleventh grade were chosen randomly from three schools in 2019/2020. The Pisa test consists of 6 questions that have aspects of SPS: measuring, applying concepts, inferring, and predicting. The problem tests of PISA resulted that 36% of students attained scores above 60. Furthermore, students' percentage could complete the measuring aspects, predicting aspects, applying concepts, and the inferring aspects were 64%, 38%, 36%, and 42%. Students' percentage based on observation instruments' results were predicting 52%, applying concepts 43%, measuring 48%, inferring 46%, experimenting 0%, asking question 23%, classifying 37%, communicating 28%, and observing 55%. These are beneficial for teachers to improve the learning process according to student needs.

Keywords: Observation Instruments; Programme for International Students Assessment (PISA) Test; Science Process Skills (SPS)

INTRODUCTION

The challenges of education in Indonesia can be categorized into internal and external challenges. The refinement of the two challenges' mindset is done by applying the 2013 curriculum with specific scientific learning models where students actively participate in problem-solving activities (Permendikbud, 2018). Furthermore, the curriculum of educational institutions should meet the needs of the working world situation. Therefore, the curriculum must improve the quality of education (Badawi & Santaria, 2020).

In the 21st century, world progress is mainly transformed by rapid science and technological advancement (Özgelen, 2012). Science education is crucial not only for developed countries but for developing countries, especially for the generation of the 21st century (Perera, Bomhoff, & Lee, 2014). Various sciences are learning at the high school education level, including physics (Asih, 2017). Physics is a natural science branch related to process, attitude, product, and technology (Kurniawan, Astalini, Darmaji, & Melsayanti, 2019). Physics is an abstract subject that requires high-level thinking that makes it difficult for students to understand physics lessons (Astalini, Kurniawan, & Perdana, 2019).

According to Desnita & Susanti (2017), physics is a science that studies the symptoms through a series of processes known as scientific processes that are built based on scientific attitudes, and the results are realized as scientific products composed of the three most essential components in the form of universally applicable concepts, principles, and theories. Unfortunately, physics is one of the fields of science that is less attractive to many students. Monotonous learning

*Correspondence Address:
Jl. Ir. Sutami 36A, Kentingan, Surakarta, 57126,
Email: estyagustiani25@student.uns.ac.id

activities and one-way communication or teacher centers increasingly make physics learning boring. A teacher is one factor that influences teaching and learning activities, success or failure (Trianto, Hartono, & Akhlis, 2019). For this reason, teachers are expected to use creative and innovative models, methods, and learning techniques in managing the learning process.

Nowadays, science process skills (SPS) are suitable for physics learning since they can build knowledge and problem-solving skills and form a scientific mindset and critical thinking (Nurjannah, Gani, Evendi, Syukri, & Elisa, & Elisa, 2020). SPS is a process of carrying out scientific activities, not hand skills using tools but using science processes so that the test subject can be in the form of a written test (Nasir, Fakhrunissa, & Nastit, 2019). Susilowati & Muhamimin (2014) also said that SPS is one of the important components that can be evaluated in physics learning. On the other hand, Harlen (2013) in Hodosyová, Útla, Vanyová, Vnuková, & Lapitková (2015) said that if SPS does not include assessments, it will lead to meaningless learning, so it is necessary to assess students' ability using another appropriate instrument.

SPS has an essential role in teaching how to attain knowledge and become a vital science education goal. Educational purpose by teaching the children these skills will also help them grow as individuals capable of accessing and understanding information (Gürses, Çetinkaya, Doğar, & Şahin, 2015). Therefore, SPS is critical to be learned and mastered by everyone. When someone masters the process skills, he has learned high-level learning skills such as conducting research and solving problems. Solving problems and conducting research is a life skill, so that SPS is the highest learning outcome students must learn (Widyaningsih, Gunarhadi, & Muzzazinah, 2020).

SPS consists of 6 aspects: observing, classifying, communicating, measuring, predicting, and inferring (Rustaman, 2005). Chiappetta & Koballa (2006) explain that the more common definition of SPS contains two levels of skills, it has been separated into Basic Science Process Skills and Integrated Science Process Skills. Meanwhile, Özgelen (2012) explain that basic SPS consists of observing, using space/time relationships, inferring, measuring, communicating, classifying, and predicting. Integrated SPS includes controlling variables, defining operationally, formulating hypotheses, interpreting data, experimenting, formulating models, and presenting the information. Friedl & Koontz (2005) suggested six sience process skills: observing, inferring, communicating, classifiying, measuring, and experimenting.

The Programme for International Students Assessment (PISA) is a triennial survey of 15-year-old students that assesses the extent to which they have acquired the critical knowledge and skills essential for full participation in society. The assessment focuses on proficiency in reading, mathematics, science, and an innovative domain. Students in Indonesia scored lower than the Organization for Economic Cooperation and Development (OECD) average in reading, mathematics, and science. Some 40% of students in Indonesia attained level 2 or higher in science (OECD average: 78%). At a minimum, these students can recognize the correct explanation for familiar scientific phenomena and can use such knowledge to identify, in simple cases, whether a conclusion is valid based on the data provided. A negligible percentage of students were top performers in science, meaning they were proficient at level 5 or 6 (OECD average: 7%. These students can creatively and autonomously apply their knowledge of and about science to various situations, including unfamiliar ones (OECD, 2019).

The formulation of the problem in this study is how the SPS aspects of senior high school students in Bojonegoro using PISA questions that have been validated the credibility of the questions by OECD.The linkage of PISA, which focuses on the field of Science with SPS, are the SPS aspects contained in the question of PISA. PISA test that is contributed consists of 6 questions that have aspects of measuring, applying concepts, inferring, and predicting. SPS is very closely related to the 2013 curriculum currently used in school, so it is necessary to measure SPS to determine how many SPS aspects of senior high school students in Bojonegoro. These results can help teachers to make appropriate improvements to improve

SPS aspects that are considered lacking and maintain SPS aspects which is good.

METHOD

The type of research conducted was descriptive research. The subject of this research was 100 students in eleventh grade chosen randomly. This research was carried out at three Senior High Schools at Bojonegoro Regency, East Java. Samples were selected based on high, medium, low levels. The schools that were randomly sampled were SMA 1 Balen, SMA 1 Baureno and SMA 1 Kedungadem. This research was conducted for two months, from July to August 2019. This research aims to determine what aspects of SPS students are low so that teachers can improve the learning process according to student needs.

The data in this research was students' SPS of PISA test and observation in class. Data collection techniques used were: (1) test techniques using PISA questions, (2) observation techniques, and (3) interviews techniques. According to Özgelen (2012), the first piece of basic SPS is gathering data about objects and events using all appropriate senses or with instruments extend the senses, such as magnifying glasses, telescopes, microphones, speakers, and medical implements. Therefore, such observation is the most basic process of science.

Observation techniques were carried out using observation instruments by taking data while learning in class. There were nine aspects of SPS used in these observation instruments: observing, classifying, communicating, measuring, experimenting, predicting, inferring, asking questions, and applying concepts. In line with Wahyuni, Indrawati, Sudarti, & Suana (2017) research that SPS has nine aspects: observing, classifying, communicating, measuring, experimenting, predicting, inferring, asking questions, and applying concepts. But, in the PISA test questions used only contain the indicator of SPS, namely measuring, predicting, applying the concepts, and inferring. So, in this PISA test, researcher only measured four aspects of SPS. In addition, interview techniques were carried out interviews with physics teachers and students. The interviews aimed to provide support and deepened the results data from the PISA test and class observation.

PISA questions used only contain in the field of science and consist of 6 essay questions. From the PISA test results, questions can be seen in what aspects of SPS appear on students, such as inferring or drawing conclusions, measuring, and predicting. The question grid of this PISA test shown on Table 1. Questions of observation instrument consist of 14 questions from 9 aspect of SPS. the scoring of the observation instrument using the Guttman scale According to Sugiyono (2014) "The Guttman scale is a scale that used to get a firm answer from the respondent, which is only there are two intervals such as “agree-disagree”; "yes-no"; "true-false"; “positive-negative”; "never-never" and so on". The grid of SPS observation instruments shown on Table 2.

Table 1. The question grid of this PISA test.

Question Number	Question Indicators based on Aspects of SPS
1a	Measuring maximum speed based on graph data
1b	Applying the concept of speed according to graphic data
1c	Predicting the distance covered with a certain probability
2a	Measuring the initial distance on a track according to graphic data
2b	Inferring the lowest speed according to the graph data
2c	Predicting the state of the car according to graphic data
2d	Inferring the results of the graphic data
3a	Measuring the volume of water in a tank
3b	Inferring the change of water level with time based on a graph
4a	Measuring the period of the lighthouse according to the diagram
4b	Inferring the period and time according to the diagram based on a graph
5	Applying the concept of swinging based on a graph
6a	Applying the concept of a drip rate of infusion fluid
6b	Measuring the volume of infusion fluid needed

Table 2. The grid of SPS observation instruments

Aspects of SPS	Number of Question
Observing	1
Predicting	2
Experimenting	3, 4
Classifying	5
Measuring	6

Inferring	7, 12
Communicating	8
Asking question	9, 10, 11
Applying	13, 14
Amount of question	14

The data analysis used was qualitative. The data obtained consist of the PISA test based on SPS, observations, and interviews. Then, the data were reduced by focusing on aspects and indicators of SPS. Furthermore, the data were presented in descriptions and tables supported by the acquisition of values in numbers and graphs. Finally, conclusions are derived and verified based on research supported by valid evidence so that the conclusions are credible and can be accounted for. The selection of the object of this study used a purposive sampling technique.

RESULTS AND DISCUSSION

The results of students' ability to solve the questions of PISA from three Senior High School in Bojonegoro: which were above the score of 60 were 36% students out of 100 students who participated in the test. The distribution of student amount for each senior high school with a score above 60 could be shown in Table 3. It is indicated that Senior High School 1 Balen more superior to another senior high school. The results agree with the last year's school rank of the National examination in Bojonegoro Regency. In addition, the three schools were not categorized as the 150 highest schools in East Java Province based on the national examination score.

Table 3. PISA Test Results of Students with A Score Above 60 in Each School

	High-Level School	Medium-Level School	Low-Level School
Amount of students	16	12	8

We show one of the question examples of the PISA instrument test based on the SPS aspect, as shown in Figure 1.

Infusions (or intravenous drips) are used to deliver fluids and drugs to patients.

Nurses need to calculate the drip rate, D, in drops per minute for infusions. They use the formula $D = dv/60n$ where d is the drop factor measured in drops per millilitre (mL). v is the volume in mL of the infusion. n is the number of hours the infusion is required to run.

Question 1: DRIP RATE (**APPLYING CONCEPTS**)

A nurse wants to double the time an infusion runs for. Describe precisely how D changes if n is doubled but d and v do not change.

Answer :

....
....
....
....

Question 2: DRIP RATE (**MEASURING**)

Nurses also need to calculate the volume of the infusion, v, from the drip rate, D.

An infusion with a drip rate of 50 drops per minute has to be given to a patient for 3 hours. For this infusion the drop factor is 25 drops per millilitre. What is the volume in mL of the infusion?

Volume of the infusion: .... mL

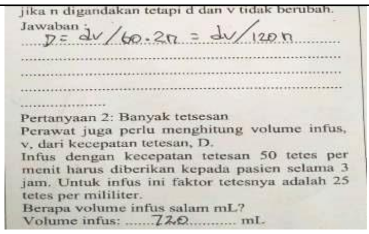
Figure 1. Example of PISA questions based on SPS aspects: Applying Concepts.

The PISA questions in Figure 1 have two aspects of SPS, namely, applying concepts and measuring. Based on applying the concept, we obtained only 4 students answered correctly, 61 students answered incorrectly, and 35 students did not answer. On the other hand, in aspect measuring, 7 students answered correctly, 62 students answered incorrectly, and 31 students did not answer. We also show one of student's answer from each school based on questions above (Figure 1), as shown in Table 4.

Table 4. Examples of student's answer from each school based on questions in Figure 1.

School	Example student's answer

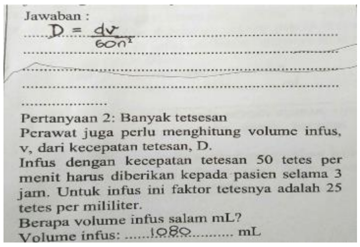
high- level school



jika n digandakan tetapi d dan v tidak berubah.
Jawaban : D= dv/60.2n = dv/120n

Pertanyaan 2: Banyak tetsesan
Perawat juga perlu menghitung volume infus, v, dari kecepatan tetesan, D.
Infus dengan kecepatan tetesan 50 tetes per menit harus diberikan kepada pasien selama 3 jam. Untuk infus ini faktor tetesnya adalah 25 tetes per mililiter.
Berapa volume infus salam mL?
Volume infus: ......720.......... mL.

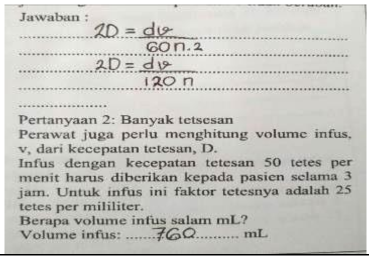
medium- level school



Jawaban : D = dv/60n²

Pertanyaan 2: Banyak tetsesan
Perawat juga perlu menghitung volume infus, v, dari kecepatan tetesan, D.
Infus dengan kecepatan tetesan 50 tetes per menit harus diberikan kepada pasien selama 3 jam. Untuk infus ini faktor tetesnya adalah 25 tetes per mililiter.
Berapa volume infus salam mL?
Volume infus: ......1080......... mL

low-level school



Jawaban : 2D = dv/60n.2
2D = dv/120 n

Pertanyaan 2: Banyak tetsesan
Perawat juga perlu menghitung volume infus, v, dari kecepatan tetesan, D.
Infus dengan kecepatan tetesan 50 tetes per menit harus diberikan kepada pasien selama 3 jam. Untuk infus ini faktor tetesnya adalah 25 tetes per mililiter.
Berapa volume infus salam mL?
Volume infus: ......760......... mL

The correct answer for question 1 is D = dv/120n and question 2 is 720 mL. From these results in Table 3, it can be seen that the eleventh-grade students in Bojonegoro High School still have difficulty in changing and substituting a formula. This difficulty can be caused by various factors such as learning activities that have not implemented aspects pf SPS and the use of teaching materials or books that have not been integrated with SPS aspects (Ratnasari, Sukarmin, & Suparmi: 2017). Therefore, teachers need to have great attention in carrying out the learning process, including paying attention to the needs of all students, so all students can learn well, becausse the different character of students has an impact in different learning patterns (Putri, Jumadi, Ariswan, & Kuswanto: 2019).

The results of the PISA test also based on the SPS aspects showed that 64% of students completed the measuring aspects, 38% of students completed the predicting aspects, 36% of students completed the applying concepts, and 42% of students completed the inferring aspects from 100 students who participated. It means that predicting and applying concepts have a higher level of questions than measuing and inferring, according to Bloom's thinking process levels. These results are shown in Figure 2.

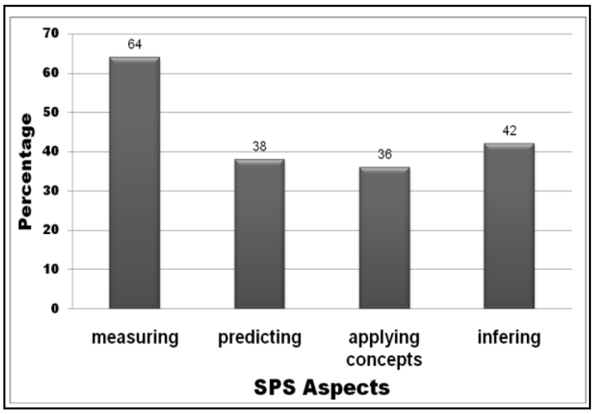


Figure 2. Percentage of students with the PISA score test based on SPS aspects.

Based on PISA test results, it showed that aspect of measuring, predicting, applying concepts, and inferring is still low. These research results in line with research results reported by Ramadhan and Wasis (2013) that the test of PISA tested has an aspect of predicting 11%, aspects of applying concepts 56%, observing aspects of 11%, and communicating 11%. The results of the research are also in line with the research of Hidayanti, Nugroho, & Sudamin (2013) that the aspects of predicting aspects and applying concepts are still low, namely 28% and 60%.

Also, it is supported by the research by Özgelen (2012) that science process skills are related to cognitive development. Developing SPS supports students' thinking, reasoning, inquiry, evaluation, problem-solving skills, and creativity. Fahmawati (2018), in her research, reported that the bad Indonesian student performance in the PISA test because science is not the same as that learned in school. Indonesian schools too focus on teaching existing skills expired like memorizing and counting ones complicated.

The observation instruments consisted of 14 statements that were used to observe and assess SPS directly in class. This observation instrument contained nine aspects of SPS: observing, classifying, communicating, measuring, experimenting, predicting, inferring, asking questions, and applying concepts. These observation instruments used the Guttman scale that wants a firm answer like yes or no and followed by the number of students who make each statement in each class. The number of students makes it easy for researchers to determine students' percentages in each SPS aspect.

The observation was conducted when the teacher was teaching Physics in the classroom. The researcher observed directly to obtain factual and relevant data. It is in line with research results by Hussin (2018) which reported that science lessons should emphasize its assessment and evaluation on science process skills aspect because science education these days has been oriented to develop students' critical thinking than only memorizing the science facts, one of them is process skill.

Table 5. Amount of students who were doing SPS aspects based on observation instruments.

Aspects of SPS	Statement	Amount of students
Observing	Students pay attention to the teacher's explanation /video / picture given by the teacher at the beginning of learning as the initial motivation for learning or observation of experimental/practical activities.	55
Predicting	Students answer questions from the teacher at the beginning of learning about a phenomenon based on the teacher's explanation or observations of videos/pictures.	52
Experimenting	Students carry out experiments/demonstrations/discussions in learning according to the steps given by the teacher.	0
Experimenting	Students use tools and materials in the demonstration/experimental activities.	0
Classifying	Students classify data obtained from experiments/ demonstrations /discussions in class.	37
Measuring	Students process data from observations/ experiments/demonstrations/discussions to find the concept being studied.	48
Inferring	Students make temporary conclusions from the results of experiments/demonstrations/discussions in discussion groups.	46
Communicating	Students convey the results obtained from the experiment /demonstration/ discussion.	28
Asking question	Students give feedback when other friends present in front of the class.	22
Asking question	Students ask questions during learning or in the question and answer process when other friends present the discussion results.	22
Asking question	Students participate in answering questions posed by other friends.	25
Inferring	Students make conclusions from the concepts learned based on the results of class discussions.	46
Applying concepts	Students can apply the concepts of Physics obtained by giving examples of phenomena in everyday life.	45
Applying concepts	Students can answer the post-test given by the teacher.	41

The results of the observation instruments shown in Table 4 show that the highest percentage of students who do aspects of SPS is 55% for observing, and the lowest is 0% for experimenting aspects. Percentage of the other aspects of SPS is predicting 52%, applying concepts 43%, measuring 48%, inferring 46%, experimenting 0%, asking question 23%, classifying 37%, communicating 28%, and observing 55%.

From the observation results, the aspects of conducting experiments are not apparent to each student. Teachers at the three schools conducted learning activities where there were no experimental or demonstration activities. Aspects of asking questions and communicating are also low because students were accustomed to being passive to ask questions and express their opinions in class.

This observation results in line with Widyaningsih, Gunarhadi, & Muzzazinah (2020) observation that teachers use more textbooks in learning science in the classroom without inviting students to explore their information causes students not to develop their skills, especially in experimenting. The textbook used also does not contain much material that develops students' practical skills. The teacher should invite students to think critically, for example, by giving questions during learning. According to Kang

(2017), in his research, teaching using pre-questions is a meaningful method to improve students' science process skills than traditional science lessons that use textbooks.

Based on the questionnaire distributed, no Physics experiment activities were conducted either in the classroom or in the laboratory. The teacher stated that the experiment made students less focused on doing it because they played more than they learned. Besides, experiment activities spent more time so that the teacher was afraid of less time delivering material. Nevertheless, the experiment tools were adequate. It is supported by the research of Ningrum, Lengkana, & Yolida (2019), which revealed that a practicum should be regularly conducted within science lessons since it allows students to develop their science process skills. Salamah & Mursal (2017) research further supports the research, which reveals that the learning model that applies experimental procedures could improve students' process skills.

The questionnaire result showed that students were glad to understand the material if the learning activities were conducted through experiments. They were also glad if the teacher gives more chances to predict the problem given. However, the counting questions had difficulties calculating the large numbers since it took much more time, even though many students passed the questions. They also claimed that there is too much formula in Physics. It makes them confused about which formula is used in specific problems. The confusion leads to the improvement of SPS in applying students' concepts. It is in line with the research results reported by Tilakaratne & Ekanayake (2017), which revealed that students' SPS could be improved when the teachers train the abilities independently by applying a learning model that employed the science process skills approach.

Table 6. Percentage of PISA test and observation instrument in each school

	PISA Test (%)	Observation Instrument (%)	Mean (%)
High-School	45.59	42.16	43.87
Medium-School	41.67	36.36	39.01
Low-School	47.73	31.99	39.86

Based on Table 6, it can be seen that the highest average aspect of the SPS based on the Pisa test and observation instruments is owned by students at high level schools. The average SPS aspect in the second position is owned by middle-level schools, and the last position is owned by low-level school students. This research is in line with research of Fadillah (2017: 1331) that the percentage of SPS aspect in school with high-level is 76.64%, school with a medium-level of 73.71%; and schools with low-level by 70.12%. Results of the PISA test and observation instruments are in line with the questionnaire distributed to students. The results of the questionnaire also showed that the aspects of SPS were still relatively low. This questionnaire was distributed to the same research object.

CONCLUSION

The students' Science Process Skill (SPS) using Programme for International Assessment (PISA) test in three Senior High Schools in Bojonegoro is still low. High-level school, medium-level school, and low-level school above the score of 60 were 35.29% students from 100 students who participated in the test. The PISA test adjusted to SPS showed that 64% of students completed the measuring aspect, 38% of students completed the pedicting, 36% of students completed the apllying concept, and 42% of students completed the inferring aspect. Based on the observation instruments results in three schools, the percentage of students doing each aspect of SPS was 37% for classifying, 48% for measuring, 52% for predicting, 46% for inferring, and 43% for applying concepts. Meanwhile, the result of the questionnaire distributed was in line with observation and PISA test questions.

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