



ANALYSIS OF SCIENCE PROCESS SKILLS OF SUMMATIVE TEST ITEMS IN PHYSICS OF GRADE X IN SURAKARTA

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ABSTRACT

The objective of this research is to analyze the science process skills (SPS) of the summative test items in physics in Surakarta. This research used a descriptive method with content analysis, namely: summative test items in Academic Year 2015/2016 in Surakarta. Each item was analyzed based on science process skill indicators prepared and elaborated by the researchers. The result and discussion of the research showed that the SPS found in the summative test items in Physics in Surakarta included those of formulating hypotheses (2.88%), designing experiments (2.10%), interpreting data (5.10%), applying concepts (70.20%), communicating (6.64%), and drawing conclusions (13.08%) respectively.

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INTRODUCTION

The aims of the education and science education today are to educate individuals who are able to adapt themselves in the different conditions, to think flexibly, to ask actively, to be creative, to think critically, to solve problems, and to appreciate other's opinions. One of which, namely: to solve problems, can be achieved with the SPS (Aktamis & Yenice, 2010). According to (Carey, et al., 1989), Science Process Skills (SPS) are special skills to simplify the science learning, to encourage students to be active, to develop students' sensitivity toward learning, and to make concepts that they have learned remain still in their mind by teaching them using scientific methods.

Comprehension learning will guide the students to connect their new experiences to their

previous experiences and concepts. Science learning with comprehension learning makes them able to describe concepts, make predictions, raise questions, examine predictions and interpret data. In other words, comprehension learning means learning by using the SPS (Harlen, 1999). In many countries, learning with the SPS has become an important component of the science curriculum at all levels and has also become one of the newest approaches in education science.

The 2013 curriculum explains that assessment on students' performance in the learning process is closely associated with their thinking skills. The students' thinking skills in building a new concept of science learning can be trained through the development of the SPS. The American Association for the Advancement of Science (AAAS) claimed that the SPS are very suitable for science learning, and science learning must be directed to learning that makes the students active, gives them real experiences, and trains their

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thinking ability.

In recent decades, Science teachers have their attention focused on the basic SPS and the integrated SPS. The SPS are very crucial for meaningful learning as the learning itself goes in the daily life, and students should be able to find, interpret and look for evidences through different conditions encountered (Karamustafaoglu, 2011).

Öztürk & Tezel, 2010 stated that SPS are a set of procedures done by scientists to conduct an investigation in an attempt to develop the knowledge. Extended training on SPS to students and developing students' SPS will be very useful for them not only as the process of building their knowledge and learning but also as their resources in everyday life.

To reach the objectives, the development of the curriculum which counts heavily on the SPS needs a feasible instrument which is able to evaluate the enhancement of SPS. Harlen (1999) stated that SPS without assessment would make the learning meaningless. Therefore, the development of an assessment instrument should be adapted to the science process skill indicators.

The importance of SPS assessment has widely been expressed by previous researchers. One of them is Harlen (1999). He stated that SPS cannot be separated from the understanding of concepts used in learning and in science implementation. However, the importance of these skills must be applied to other materials (besides science) because the core of learning is comprehension, both in formal education and everyday life. That is the reason why assessment in the SPS is important.

The results of research conducted by Hofstein & Lunetta, (2004) suggested that some schools still fail to assess the results of laboratory activities appropriately. Further, Hofstein & Lunetta emphasized the importance of authentic assessment alternative, which is able to measure SPS in school. However, although digital era primarily focused on a high standard approach to science education, the assessment model in a science lab is still conventional through the use of paper and pencil test. In addition, measurements for developing standardized test forms have not maximally been done. As a result, the development and the assessment of the SPS become important. Although there are difficulties in the implementation of the authentic skill assessment, the technical problems can be solved as long as there is a will to do so (Temiz, 2006).

One of the assessments conducted by the teachers is the scoring on the summative test. The materials of the summative test items contain matters that the teachers have taught in one semester. The summative test became one of the students' comprehension benchmark of the materials. However, the development of summative test generally is focused on the cognitive aspect, without considering the student's SPS. This causes the concept to be less internalized to the students' mind as they are required to merely memorize, not to do a process of digging the information. Thus, the objectives of this research are to analyze the summative test items in Surakarta and to investigate to some extent how the SPS are applied in the assessment.

METHODS

This research used the descriptive method. A design of descriptive research attempted to illustrate; what, how, or why something happens. A descriptive research uses samples to document, describe, and explain whether or not there are phenomena in the studied matter. The data of the research were collected through content analysis, namely: the analysis of the summative test items in Academic Year 2015/2016, which was used in some schools in Surakarta. Purposive sampling technique was employed to determine its samples by selecting the schools that represented the high, medium, and low categories of both state and private schools. The samples consisted of 6 samples of summative test items from six different schools in Surakarta.

The data of the research were collected through a checklist, which was prepared according to the science process skill indicators. The science process skill indicators in this research included formulating hypotheses, designing experiments, analyzing the data, applying concepts, communicating, and drawing conclusions. Each item was analyzed based on the science process skill indicators. The occurrence of each indicator was tabulated, and the average of the occurrence of each indicator was then calculated. In addition, the analysis was also done on the material's categories. The results were tabulated and averaged. Based on the average of science process skill indicators' occurrence, it could be known how the summative test items in Surakarta were developed. The SPS indicators which were too dominant and the indicators which did not appear at all could be analyzed.

RESULTS AND DISCUSSION

The summative test items from some schools in Surakarta were analyzed based on the six SPS indicators with their aspects. The analysis was conducted on each item and material in the summative test items in Physics of Grade X in

Semester 2 in Academic Year 2015/2016, which consists of the learning materials of Elasticity; Static Fluid; Heat, Temperature and Heat Transfer; and Optical Instrument. Each occurrence indicator was calculated and averaged. The result of material analysis based on the SPS is presented table 1.

Table 1. The Analysis Result of the SPS on Each Learning Material (Continued)

| Material | Summative Test A | | | | | | Summative Test B | | | | | | Summative Test C | | | | | |
|-------------------------------------|------------------|-----|-----|------|---|-----|------------------|-----|-----|------|------|------|------------------|-----|------|------|---|-----|
| | SPS Indicators | | | | | | SPS Indicators | | | | | | SPS Indicators | | | | | |
| | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3 | 4 | 5 | 6 |
| Elasticity | 0 | 0 | 0 | 5 | 1 | 0 | 0 | 0 | 1 | 5 | 3 | 2 | 0 | 0 | 1 | 4 | 0 | 0 |
| Static Fluid | 0 | 1 | 0 | 5 | 0 | 2 | 2 | 1 | 0 | 8 | 0 | 4 | 1 | 1 | 3 | 4 | 0 | 0 |
| Heat, Temperature and Heat Transfer | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 3 | 0 | 0 | 1 | 9 | 0 | 2 |
| Optical Instrument | 0 | 0 | 1 | 11 | 0 | 1 | 0 | 0 | 0 | 4 | 3 | 2 | 0 | 0 | 0 | 9 | 0 | 0 |
| Occurrence Average | 0 | 1 | 1 | 33 | 2 | 3 | 2 | 1 | 1 | 24 | 6 | 11 | 1 | 1 | 5 | 26 | 0 | 2 |
| Total Item | 40 | | | | | | 45 | | | | | | 35 | | | | | |
| Percentage (%) | 0 | 2.5 | 2.5 | 82.5 | 5 | 7.5 | 4.4 | 2.2 | 2.2 | 53.3 | 13.3 | 24.4 | 2.9 | 2.9 | 14.1 | 74.1 | 0 | 5.7 |

| Material | Summative Test D | | | | | | Summative Test E | | | | | | Summative Test F | | | | | |
|-------------------------------------|------------------|---|-----|------|------|-----|------------------|---|-----|------|-----|----|------------------|---|------|----|-----|------|
| | SPS Indicators | | | | | | SPS Indicators | | | | | | SPS Indicators | | | | | |
| | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3 | 4 | 5 | 6 |
| Elasticity | 0 | 0 | 1 | 5 | 3 | 1 | 0 | 0 | 1 | 3 | 2 | 1 | 0 | 0 | 1 | 2 | 0 | 1 |
| Static Fluid | 0 | 2 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 7 | 0 | 3 | 1 | 0 | 0 | 4 | 0 | 2 |
| Heat, Temperature and Heat Transfer | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 1 | 6 | 0 | 3 | 2 | 0 | 0 | 11 | 0 | 0 |
| Optical Instrument | 0 | 0 | 0 | 6 | 2 | 2 | 0 | 0 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 4 | 1 | 1 |
| Occurrence Average | 0 | 2 | 1 | 29 | 5 | 3 | 0 | 0 | 2 | 24 | 2 | 7 | 3 | 0 | 1 | 21 | 1 | 4 |
| Total Item | 40 | | | | | | 35 | | | | | | 30 | | | | | |
| Percentage (%) | 0 | 5 | 2.5 | 72.5 | 12.5 | 7.5 | 0 | 0 | 5.7 | 68.6 | 5.7 | 20 | 10 | 0 | 3.33 | 70 | 3.3 | 13.3 |

Notes:

Indicator 1: formulating hypotheses; Indicator 2: designing experiments; Indicator 3: analyzing data; Indicator 4: applying concepts; Indicator 5: communicating; indicator 6: drawing conclusions

Table 1 shows kinds of SPS that appeared on the summative test items. On Summative Test A, the skill of formulating hypotheses did not appear at all. Meanwhile, the skill of applying concepts became the most dominant skill which was 82.5%. The skills of designing experiments and analyzing the data only appeared in 1 question

item of each learning material. The skill of applying concepts became the most dominant skill on each material. On the materials of Heat, Temperature and Heat Transfer, the skill of applying concepts (Skill 4) appeared in each test item while the skills of 1, 2, 3, 5 and 6 did not appear at all.

On Summative Test B, the SPS indicators was more evenly spread compared to the Summative Test A though the skill of applying concepts still became the one that appeared mostly on the question items. All of the SPS indicators which were analyzed appeared on Summative Test B. Thus there was no percentage occurrence of 0. However, similar to Summative Test A, on the materials of Heat, Temperature, and Heat Transfer, almost all question items were in the form of skill of applying concepts, while the skills of formulating hypotheses, designing experiments, analyzing data and communicating did not appear at all.

Summative Test C was not much different from Summative Test A and B. The skill of applying concepts still became the skill that often appeared on each summative test. While the skill of communicating did not appear at all on each material. In Optical Instrument material, the skill that appeared was that of applying concepts. The certain skills that appeared made the question items less variation and only able to measure one type of skill.

Summative Test D had a pattern of occurrence which was almost similar to the others. The dominant skill was the skill of applying concepts. The skills of formulating hypotheses became the skill whose percentage occurrence was 0%. On the materials of Temperature, Heat, and Heat Transfer, the skill that appeared was that of applying concepts while other skills did not appear at all.

The skill of applying concepts also became the indicators which often appeared on Summative Test E. Even on the material of Optical Instrument, the skill of applying concepts was the only skill that appeared. The skill of formulating hypotheses and that of designing experiments did not appear at all on each material.

Summative Test F was also similar to Summative Tests A, B, C, D, and E. They were still dominated with the skill of applying concepts while the other skills only appeared on some materials or did not appear at all.

Based on the analysis of each Summative Test, the occurrence pattern of indicators was almost similar on each summative test. The frequently occurred indicator was the skill of applying concepts while the indicators that rarely occurred were formulating hypotheses and designing experiments.

Duruka, et al., 2017 stated that the hypotheses were data based on the previous knowledge and repeated observations; or, explanations concluded from observations. This skill became one of the skills that rarely appeared on each summative test. This should be a concern because this skill becomes one of the important components in science learning. It is similar to the claim of Kuhn & Dean, (2005) who stated that the skill of formulating hypotheses becomes an important component in scientific and inquiry matters, since it is important for the students to search for information by submitting hypotheses so that the students will attempt to find out the answers to the hypotheses.

Besides, the skill of designing experiments also becomes an important component in science. It is similar with Karamustafaoğlu (2011) who stated that SPS are developed based on the activity of the laboratory. Through the activities of the laboratory, the students gain meaningful learning, use the SPS, and become familiar with the process of constructing the information obtained in the science learning.

After the summative test was analyzed, each indicator was summed up and averaged by their occurrences. The data analysis result of each science process skill indicator are presented in table 2.

Table 2. Analysis of Each Science Process Skill Indicator

| Science Process Skill Indicators | Summative Test | | | | | | | | | | | | Average |
|----------------------------------|------------------|-----|------------------|-----|------------------|------|------------------|-----|------------------|-----|------------------|-----|---------|
| | Summative Test A | | Summative Test B | | Summative Test C | | Summative Test D | | Summative Test E | | Summative Test F | | |
| | Σ | (%) | Σ | (%) | Σ | (%) | Σ | (%) | Σ | (%) | Σ | (%) | |
| Formulating Hypotheses | 0 | 0 | 2 | 4.4 | 1 | 2.9 | 0 | 0 | 0 | 0 | 3 | 10 | 2.9 |
| Designing experiments | 1 | 2.5 | 1 | 2.2 | 1 | 2.9 | 2 | 5 | 0 | 0 | 0 | 0 | 2.1 |
| Analyzing Data | 1 | 2.5 | 1 | 2.2 | 5 | 14.3 | 1 | 2.5 | 2 | 5.7 | 1 | 3.3 | 5.1 |

| | | | | | | | | | | | | | |
|---------------------|----|------|----|------|----|------|----|------|----|------|----|------|-------|
| Applying Concepts | 33 | 82.5 | 24 | 53.3 | 26 | 74.3 | 29 | 72.5 | 24 | 68.6 | 21 | 70 | 70.20 |
| Communicating | 2 | 5 | 6 | 13.3 | 0 | 0 | 5 | 12.5 | 2 | 5.7 | 1 | 3.3 | 6.6 |
| Drawing Conclusions | 3 | 7.5 | 11 | 24.4 | 2 | 5.7 | 3 | 7.5 | 7 | 20 | 4 | 13.3 | 13.1 |
| Total Items | 40 | | 45 | | 35 | | 40 | | 35 | | 30 | | |

Table 2 shows the average occurrence of each indicator at all summative tests which made the samples can be analyzed. The indicators having the largest percentage of occurrence on average was the skill of applying concepts, which was 70.20%.

The domination of the skill of applying concepts indicated that Physics learning was all this time oriented to memorizing concepts not to find concepts. This should become our serious concern because the students should gain a meaningful learning through SPS. According to Harlen (1999), through meaningful learning, the students will continue to learn throughout their life. It is, therefore, very important to give SPS in educational institutions.

The skill of designing experiments became a skill that had the least percentage occurrence. The skill should be the compulsory one extended to the students. Akani (2015) stated that designing experiments and observation became a key to activity in science learning, so that it became an important component in learning, teaching and implementing science. Germann (1994) revealed that the primary purpose of science learning was to help the students to construct knowledge-centered phenomenon in science, and at the same time, to help the students to disclose the reasons, think critically, and to resolve the issues. One of the ways to materialize it is inquiry-based learning in the laboratory, which emphasized the basic SPS and the integrated SPS.

The importance of designing skill experiments was also expressed by Duruka et al. (2017) who stated that discovery-based learning would make the students use the high level thinking skill to draw conclusions based on the evidence. In the process of designing experiments, the students used some skills of science such as; collecting data, identifying variables, formulating hypotheses, and others. Meanwhile, the skills of designing experiments became the important SPS due to the combination of many skills for deeper analysis when conducting the experiment repeatedly.

In addition to the skill of designing experiments, the skill of formulating hypotheses beca-

me one of the skills which appeared little on the summative test. The average occurrence of this skill was 2.88%. The skill of formulating hypotheses was inseparable from the skill of designing experiments. Both became the characteristics of the science learning. One of the caused of the low average occurrence of formulating skill hypotheses was that the textbook used by the teachers did not contain SPS. This result of the research is in line with that of the research conducted by Tatar & Feyzioglu (2012) who claimed that most of the results of the study show that the science textbook for Senior Secondary Schools did not contain SPS or contain SPS which are separable at each level and which have the smallest representation on the skill of formulating hypotheses.

Other skills such as the skill of analyzing data, the skill of communicating, and the skill of drawing conclusions also had a low level of occurrence. According to Sukarno et al. (2013), the low percentage of the occurrence of SPS indicators is due to the fact that the assessment of students' competence all this time only has only been focused on the mastery of concepts. Besides, the teachers less understand how to develop an instrument which is capable of measuring the SPS of the students. Furthermore, Sukarno et al. (2013) stated that one way to overcome this situation is providing the science teachers with the training of SPS. The training consists of knowledge of the SPS, the SPS indicators, and the SPS assessment. Through training, teachers are expected to be able to apply their knowledge in developing the SPS through their students.

The results of research conducted by Foulds & Rowe, (1996) showed that teachers and students still rarely develop the SPS. The students have weakness in developing the skill analyzing problems, and in designing and controlling the experiments. The science learning integrated with the development of science process skill demands a laboratory activity. Thus, teachers are expected to be able to improve the students' SPS through the laboratory activity.

SPS are thinking skills used by scientists to build knowledge for problem-solving. Scientific

methods, scientific mindsets, and critical thinking are terms of this skill, so that for at least two decades, SPS have become more commonly heard (Özgelen, 2012)

The importance of the SPS has been widely recognized. The SPS become the main goal of the science learning. It is used not only by scientists, but also by everyone who wants to be an educated scientist. It can be said that teaching the science means teaching the SPS (Harlen, 1999; Mohd, 2004)

The SPS have become the important skills, not only for the preparation of scientists and technologists in the future, but also for the vast majority of people who need science literacy for life where science affects most aspects of personal, social and global life (Harlen, 1999). The SPS will help students to become problem-solvers so that they are able to apply these skills in the context of the real world (Monhardt & Monhardt, 2006).

The SPS also have a positive impact on the learning achievements of students. Earlier studies showed a positive correlation between the academic achievement and the SPS (Beaumont-Walters & Soyibo, 2001; Delen & Keserciodlu, 2012; Sinan & Usak, 2001). The SPS and the academic achievement are interconnected for the students 'conceptual change process. To develop a high level of conceptual changes requires the SPS. Therefore, the SPS cannot be separated from the conceptual changes and conceptual understanding (Karamustafaoglu, 2011).

The SPS can be seen as factors that support the understanding of the concepts because the SPS are correlated with the academic achievement. The students' ability in mastering the concepts of Physics requires some skills, such as skills to solve problems, SPS and ability of thinking and reasoning (Usmeldi, 2016). In addition, according to Rani, et al. (2017), the SPS are also needed to get an understanding of the concepts in the learning process.

The importance of SPS in science learning including Physics and the positive correlation between the SPS and the academic achievement become the reason of why the assessment including the SPS indicators become very important to be developed. Assessment can be done through the daily test, semester-mid test, or summative test.

CONCLUSION

In conclusion, the average occurrences of the science process skill indicators on the summative test items in Surakarta were as follows: (1) the skill of formulating hypotheses was 2.88%;

(2) the skill of planning experiments was 2.10%; (3) the skill of analyzing data was 5.10%; (4) the skill of applying concepts was 70.20%; (5) the skills of communicating was 6.64%; and (6) the skill of drawing conclusions was 13.08%.

The results of this research are expected to be a reference for teachers who want to develop assessment instruments that contain the SPS indicators. The disadvantages and advantages of each summative test item can be a reference for the development of summative test items in the next academic year.

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