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A Study on Awareness Levels of Prospective Science Teachers on Science Process Skills in Science Education

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Abstract: The purpose of this study is to determine the awareness levels of prospective science teachers (PST) on science process skills using a qualitative and quantitative analysis. The study was carried out in the form of a case study with 40 senior prospective science teachers in the academic year of 2007-2008 at the Faculty of Education, Giresun University, Turkey. A science process skills questionnaire and a science process skills test consisting were prepared and applied to the senior PST. According to the data obtained from the questionnaire and the test results, the PST who could explain science process skills theoretically had difficulty when transferring the theoretical knowledge into the practice.

Key words: Awareness levels · Science process skills · Prospective science teachers · Teacher training · Science education

INTRODUCTION

In the curriculum of science and technology course in elementary schools, implemented by the Ministry of National Education of Turkey (MNE- TR) in 2006, the idea of the literacy of science and technology is emphasized in seven categories, one of which is the science process skills. The curriculum requires that students should use science process skills during making a decision and problem solving because science process skills are fundamental to science, allowing everyone to conduct investigations and drawing conclusions [1].

Science process skills are defined as the adaptation of the skills used by scientists for composing knowledge, thinking of problems and drawing a conclusion. It can also be stated as the qualifications each individual is supposed to have in societies aiming to educate all people as science literate [1, 2]. Cepni *et al.* [3] also defined as facilitating basic activities as regards learning science, gaining research method and techniques, helping students to be active and to make learning permanent. Science process skills are classified as basic (observing, measuring, classifying, collecting data and using number relationships), causal (predicting, identifying variables and drawing a conclusion) and experimental (formulating hypotheses, making models, experimenting, controlling variables and making a decision) [4]. All of these science process skills are complementary of each other. Science process skills provide that students reach the meaningful learning at physics, chemistry and biology courses. Moreover, science process skills prevent the memorization of facts and developing negative attitudes in science [2, 5] and besides, science process skills also have great influence on education because they help students to develop higher mental processes such as problem solving, critical thinking and making a decision [6-9]. In order to get students to gain science process skills, teachers have some important responsibilities. These are arranging learning activities and the learning environment, teaching the ways of reaching information, determining of the development of students' science process skills levels and improving students' science process skills [8,10-12]. Therefore, science process skills are important in teacher training programs. Prospective Science Teachers (PST) should be informed about the importance of science process skills for science and technology course. Also, it is important that science process skills of PST should be examined, for it is essential to know PST' background on science process skills to plan the activities improving their science process skills.

MATERIALS AND METHODS

The study was carried out in the form of a case study in the academic year of 2007-2008 at the Faculty of

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Education, Giresun University, Turkey. The purpose of using case study method is to examine PST' science process skills in detail [13,14]. The sample group is 40 senior PST, at the Department of Elementary Science Teacher Training.

The science process skills questionnaire and the science process skills test were used as the data collection tools and both were applied to 40 PST. The questionnaire including 6 open ended questions was applied to determine the awareness levels of PST and their views on the improvement of their own science process skills. The data of questionnaire were analyzed with the descriptive and content analysis methods. In the content analysis, the data obtained from the open ended questions were coded in accordance with the related themes. The frequencies of the codes were computed and tabulated. In the descriptive analysis, the statements of the students relating themes were presented for data reliability. The students were represented with numbers from 1 to 40 in the tables.

There are 25 questions in the science process skills test. These questions were randomly selected from the each modules of "Test for Assessing Science Process Skills" [2]. At the development stage of the science process skills test, 22 multiple choice and 3 open ended questions were selected from the question pool consisting of 6 modules. The names of these modules are "identifying variables and formulating hypotheses", "controlling variables and experimenting", "collecting data and preparing data table", "drawing graph", "interpreting the data and reading graph", "identifying variables and formulating hypotheses". A pilot study was done for the reliability and validity of the test. For item analysis the discrimination and difficulty indices were calculated. For the test reliability, Pearson's moment correlation coefficient was computed as 0.91 and it was corrected to 0.95 with Sperman-Brown. Expert opinions were taken into account for the reliability of the open ended questions and for the validity of the science process skills test. In the test, there are eight multiple choice questions in the first module, four multiple choice questions in the second module, one open ended question in the third module, one open ended question in the fourth module, ten multiple choice questions in the fifth module and one open ended question consisting of three phase in the sixth module.

The multiple choice questions of the test were analyzed as the percentages of the true answers. The data obtained from the open ended questions were analyzed with Temiz (2007)'s analytical criteria. The data are presented in figures and tables.

FINDINGS

Forty PST' views about science process skills and awareness levels of their science process skills were determined by the questionnaire and the science process skills test. Findings of the questionnaire and the test are given in the following.

The Findings of The Questionnaire:

Question 1: What are science process skills? Can you explain?

As shown in Table 1, the majority of PST used basic process skills (18 PST), experimental process skills (15 PST), Bloom's Taxonomy (11 PST), problem solving (9 PST), scientific method and technical skills themes (7 PST) when explaining science process skills. However, the minority of them used the themes of laboratory (3 PST), deduction – induction (3 PST) and causal process skills (1 PST).

Question 2: What do you think about the relationship between science and technology instruction program and science process skills? Explain it with the examples.

As shown in Table 2, the majority of PST explained the relationship between science and technology instruction program and science process skills with the themes of "research and experiment" (19 PST).

Question 3: In your opinion, which one of your science process skills developed better than the others? Can you illustrate?

As shown in Table 3, 14 PST stated that their basic process skills developed more than the others, 3 PST stated that their causal process skills developed more than the others, 18 PST stated that their experimental process skills developed more than the others, 4 PST pointed out that their all science process skills developed equally. 18 PST answered the question irrelevantly.

The frequency range of the best improved science process skills of PST thought that they have is given in Figures 1, 2 and 3 below. In these figures, "observing" from basic process skills (8 PST), "drawing a conclusion" from causal process skills (2 PST), "experimenting" from experimental process skills (13 PST), have high frequencies.

Table 1: The ideas of PST on the science process skills

Themes	Example statements of PST	Frequency
Basic process skills	"Observing, classifying, explanation" (23) "Observing" (28)	18
Causal process skills	"Causal skills" (10)	1
Experimental process skills	"Formulating hypotheses, collecting data" (33) "Experimenting, identifying variables, making a decision" (12)	15
Bloom's Taxonomy	"Knowledge, comprehension, application, analysis, synthesis, evaluation" (7)	11
Piaget's Formal Operation Stage	"Hypothetical-deductive, combinational, oriental, proportional thinking" (31)	5
Problem solving	"Problem solving" (16)	9
Laboratory	"Open-ended and close-ended experiments which are made in the laboratory." (35)	3
Deduction-induction	"The activities of deduction and induction for a new product"(37)	3
Scientific method, technical skills	"Usage of scientific method and having technical skills on this process" (13)	7
Other explanations	"Objectives are acquired with education and instruction." (3)	5

Table 2: The ideas of PST on the relationship between science and technology instruction program and science process skills

Themes	Example statements of PST	Frequency
Research and experimenting	"There is a positive relationship because science and technology is mostly based on research and experiment." (25) "Experimenting provides students involved actively in the lesson." (29)	19
Nature of science	"It is essential to comprehend nature of science in order to understand science." (27)	2
Abstract concepts	"Science and technology course consists of abstract concepts." (11)	6
Bloom's Taxonomy	"Various applications can be done in order students to gain cognitive, affective and psychomotor process skills." (3)	3
Appropriate environment and attractive material	"To use the science process skills an appropriate environment and attractive material" (36)	1
Nature	"Science deals with the nature and natural events." (34)	2
Free discovery	"Free discovery method is mostly used in science." (5)	5
Constructivism	"Science curriculum is based on constructivist approach" (5)	2
Thinking skills	"Criticism, creativity, hypothesis is related to the science." (4)	5
Problem solving	"Problem solving is appropriate for the science and requires science process skills." (6)	4
Cumulative relation	"There is a cumulative relation." (7)	1
Understanding, evaluating and using the knowledge	"Students can understand the source of their knowledge and how the knowledge works." (37)	6
Observing	"We observe a problem and then analyze it." (9)	4
Cause and effect relation	"Science requires cause and effect relationship." (3)	2
Technical skills	"Teachers have theoretical knowledge and they can use it technically." (13)	2
Student centered learning	"In science and technology instruction program, the instruction should be learner-centered." (19)	2
Others	-	8

Question 4: What are the factors affecting your science process skills' development?

As shown in Table 4, the majority of PST stated that the factors affecting their development of science process skills are learning environment (10 PST), personal attributes (11 PST), experiments and documentary films (9 PST), experience (6 PST) and daily life (4 PST).

Question 5: Can you explain your opinion on the contribution of physics, chemistry and biology to the development of science process skills as a comparison?

a. The courses of physics, chemistry and biology contribute to the development of science process skills in equal amounts because................................

b ……..course contributes more than the others because………………………..

Table 3: The ideas of PST on their science process skills

Themes	Sub themes	Example statements of PST	Frequency
Basic process skills	Observing	"I think my observing skill is developed." (37)	8
	Measuring	"I think my measuring ability is developed." (16)	2
	Classifying	"Classifying" (19)	1
	Collecting data	"First time, we define the problem and then record the data." (6)	3
	Using number relationships	-	-
Causal process skills	Predicting	"We formulate hypotheses and then we predict the result." (6)	1
	Identifying variables	-	-
	Drawing a conclusion	"In the new science curriculum, deductive method is used." (17)	2
Experimental process skills	Formulating hypotheses	"We define a problem, collect the data and formulate hypotheses." (5)	3
	Making models	-	-
	Experimenting	"When experimenting, my science process skills are improved." (14) "I like doing experiments and using causal relations in problems." (32)	13
	Controlling variables	"I think my testing ability is developed." (37)	2
	Making a decision	-	-
The same level	"I do not think that one of the science process skills is dominant to others." (38) "I think that all of my science process skills are developed." (9)		4
Irrelevant	Free discovery	"I acquire the knowledge with free discovery." (22)	1
	Research and investigation	"I try to search every kind of problems in science topics." (24)	1
	Problem solving	"Problem solving" (29)	3
	Multiple intelligence theory	"I use all the science process skills in the multiple intelligence theory." (31)	1
	Bloom's Taxonomy	"In general, it is easy to apply cognitive abilities." (40)	7
	Creative thinking	"My creative thinking ability is developed." (39)	1
	Critical thinking	"I can think of a concept critically." (15)	1
	Irrelevant	-	4

Table 4: The ideas of PST on the factors affecting the development of science process skills

Effecting Factors of science process skills	Example statements of PST	Frequency
Learning environment	"Properties of the school, apparatus for research" (11)	10
Personal attributes	"Personal characteristics affect thinking skills." (33) "Interest to lesson" (28)	11
Phenomena	"Interesting and natural phenomena require predicting." (34)	1
Scientists' lives	"Scientists I saw are attractive." (35)	1
Models, activities and technology	"Models science teacher had showed were effective." (36)	3
Daily life	"Real life is important for people." (23)	4
Experiments and documentary film	"My education and the experiments we performed at the school" (5) "Doing experiments in the laboratory and documentary film" (38) "Doing experiment is an important factor." (12)	9
Experience	"In order to develop a skill, you need to practice it." (39) "My observations and the scientific journals which I read" (4)	6
Others	-	3

In Table 5, PST' ideas on the effect of physics, chemistry and biology courses existing in science and technology instruction program on the development of science process skills are given in detail. 21 PST stated that three courses contributed equally to the development of science process skills. 8 PST stated that physics affected more than the others, 7 PST stated that physics and chemistry affected more than the others, 2 PST stated that chemistry affected more than the others, 1 PST stated that biology affected more than the others.

Question 6: What can be done in order to improve students' science process skills? Please prepare an activity to improve your students' science process skills by considering your branch.

PST could not prepare any activities in this question. But, they gave some recommendations that experiments should be done and the activities should be student centered in the courses.

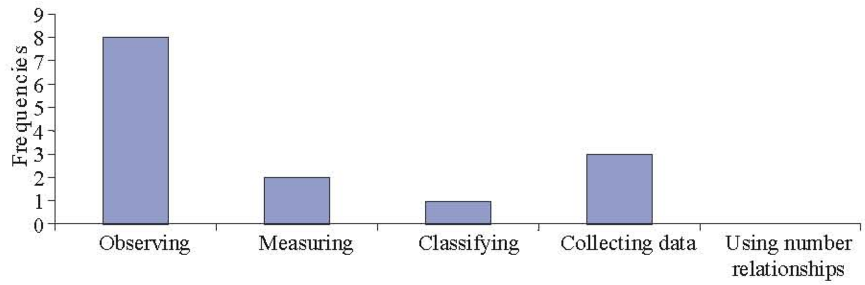

Fig. 1: The frequencies of students' answers on basic process skills in the questionnaire

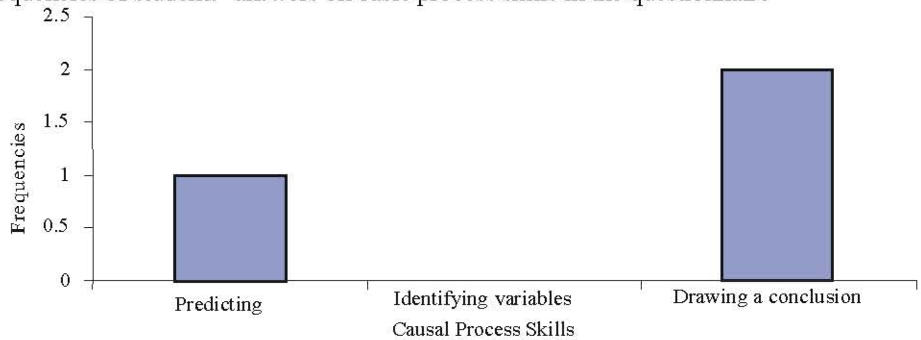

Fig. 2: The frequencies of students' answers on causal process skills in the questionnaire

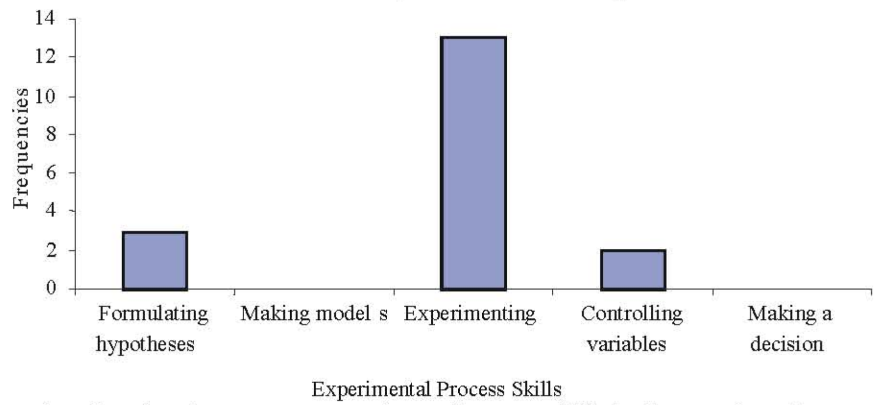

Fig. 3: The frequencies of students' answers on experimental process skills in the questionnaire

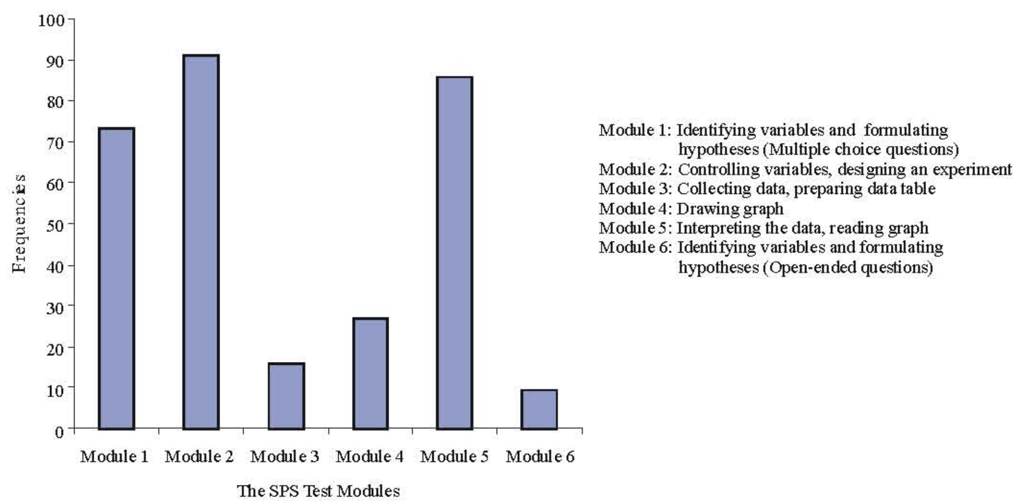

Fig. 4: The percentages of average points of students taken from each module of the science process skills test

Findings of The Science Process Skills Test: The data obtained from the science process skills test were examined in the separate modules. As denoted in Figure 4, the modules 2, 5 and 1 have the true answers frequencies of 91.25, 85.75 and 73%, respectively. The modules 4 and 3 have the true answers frequencies of 26.88 and 15.75%, respectively. The module 6 has the true answers' frequency of 9.38%.

DISCUSSION

This study examines the determination of awareness levels of PST on science process skills. There are some main studies on science process skills in the literature [6,9,15-18]. These studies deal with learning approaches in students' education and PST training. Tatar, Korkmaz and Sasmaz Oren [19], explained that Vee and I Diagrams affect the development of science process skills in their review study. There are also review studies defining science process skills and its role in education [7,8]. Science teachers have important responsibilities in order to improve students' science process skills. It is expected that teachers should examine their own development of science process skills. Science process skills are very important in teacher education in order for teachers to be able to be aware of the importance of science process skills. If science process skills are applied to the course process of PST, they can acquire science process skills. Therefore, their students can also acquire science process skills.

In this part of the study, the data obtained from open ended questions and science process skills test were discussed. As shown in Table 1 above, PST defined science process skills with the themes of "observing" and "classifying" from among basic process skills (18 PST); "formulating hypotheses", "experimenting" and "controlling variables" from experimental process skills (15 PST). But they did not mention "measuring", "collecting data" and "using number relationships" from among causal process skills; "making models" and "making a decision" from among experimental process skills. Only one PST mentioned causal process skill superficially. This case can be interpreted that PST possibly memorized and could not comprehend the theoretical knowledge on science process skills. On the other hand, some PST confused the science process skills with the themes of Bloom's Taxonomy (11 PST), Piaget's Formal Operation Stage (5 PST) and problem solving (9 PST).

In the Table 2 above, the PST used these themes as research and experimenting (19 PST), nature of science (2 PST), abstract concepts (6 PST), appropriate learning environment and attractive material (1 PST), nature (2 PST), free discovery (5 PST), constructivism (2 PST), thinking skills (5 PST), problem solving (4 PST), understanding, evaluating and using the knowledge (6 PST), observing (4 PST), cause and effect relation (2 PST) and student centered learning (2 PST) for describing the relation between science and technology instruction program and science process skills. Some of the PST stated that science process skills provide benefits for science and technology instruction program when describing the relation between science and technology instruction program and science process skills. But most of PST could not connect the relationship with science and technology instruction program and science process skills due to using Bloom's Taxonomy as in the first question and constructivism concepts. According to these findings, it can be stated that PST could not try to relate science process skills with the themes they used in their answers.

As shown in the Table 3 above, the PST pointed out that their capabilities of "observing", "measuring", "classifying", "collecting data" from among basic process skills; "predicting" and "drawing a conclusion" from among causal process skills; "formulating hypotheses", "controlling variables" and "experimenting" from among experimental process skills were developed. In other way, some of the PST stated that some other capabilities such as Bloom's Taxonomy, creative and critical thinking, problem solving were developed. As PST described some of the science process skills, they used the themes of Bloom's Taxonomy, problem solving and Piaget's Formal Operational Stage, too. It seems that the PST confused science process skills with especially Bloom's Taxonomy and problem solving. Additionally, the data of these findings were shown in the figures 1, 2 and 3. This result can be interpreted that their "using number relationships", "drawing a conclusion" and "making models" process skills are not developed or they are not aware of having these skills.

In the Table 4 above, the PST said that learning environment, personal attributes, phenomena, scientists' lives, models and activities, technology, daily life, experiments and documentary film and experience are important factors for the development of science process skills. PST stated different factors affecting the development of science process skills. As the reason of this case, it can be stated that PST had different view points, personal features and experiences.

As shown in the Table 5 above, PST stated that physics, chemistry and biology courses affect the

Table 5: The ideas of PST on the contribution of physics, chemistry and biology to science process skills

Courses	Example statements of PST	Frequency	Percentage
Physics, Chemistry and Biology	"Science is related to the nature and research. Physics, chemistry and biology provide the contribution to the science process skills equally." (13) "Physics, chemistry and biology can not be thought separately because our starting point is the nature." (37) "All of them are effective at improving the science process skills." (40)	21	52.5
Physics	"Physics is more applicable than the others and it requires laboratory." (5) "Physics has more abstract concepts and we can define these concepts with using science process skills." (39)	8	20.0
Chemistry	"Chemistry provides students to think productive." (17)	2	5.0
Biology	"Biology analyses people." (1)	1	2.5
Physics and Chemistry	"In these courses, there are application methods." (7) "Physics and chemistry require the laboratory." (25)	7	17.5
Not Answered	-	1	2.5

Table 6: The relationship with the example activity and science process skills

The stage of the example activity	Science process skills
1. Formulate a hypothesis to determine whether the brightness of lamps is dependent to the resistances of conductive wires.	Identifying variables and formulating hypotheses
2. Determine the dependent, independent and controlled variables in your hypothesis.	Controlling variables,
3. Design an experiment with the materials given below to test your hypothesis.	Designing an experiment, Collecting data, observing, experimenting
4. Prepare a data table using the experiment findings	Preparing data table
5. Draw the graph of the brightness of lamps versus the resistance wires.	Drawing graph
6. Make interpretations about your graphs. Draw a conclusion from the findings of the experiment.	

development of their own science process skills. 21 PST explained that all three courses affect science process skills equally. 7 PST explained that physics and chemistry affect equally. One PST did not answer the question. The rest of the PST stated that one of the courses affect more than the others. When the Table 5 is examined in detail, it can be seen that biology course had the lowest frequency. This situation can be related with teaching methods in biology course. The reason of choosing one course affecting more than the others can be stated that PST were interested in the chosen science branches.

When the preparation of an activity was expected from PST, it was seen that PST could not prepare any activities. The PST recommended only "experimenting" and "using student centered teaching methods". The majority of the PST stated that experimenting was the most developed skill from their science process skills. However, it was found that the identifying variables and formulating hypotheses skills which were needed for experimenting had a low answering percentage in the science process skills test. The PST who could explain science process skills theoretically had difficulty when transferring the theoretical knowledge into practice. It was seen that PST were not aware of the development of their own science process skills. True answering percentage of the PST is higher in multiple choice questions and is lower in open ended questions. This situation can be explained with that multiple choice questions including alternatives implying true answers and open ended questions require recalling and applying knowledge.

Most of the PST stated that they had the ability of doing experiment. But, as the data obtained from the science process skills test was considered, module 3, 4 and 6 respectively "collecting data and preparing data table" (15.75% PST), "drawing graph" (26.88% PST) and "identifying variables and formulating hypotheses" (9.38% PST) had lower percentage of true answers. Experimenting requires having the ability of collecting data, preparing data table, drawing graph, identifying variables and formulating hypotheses. All the results taken into account, it appears that there was no consistency between science process skills PST thought that they have and science process skills they applied in practice. PST had the highest true answering percentage on the module 1 (73% PST), 2 (91.25% PST) and 5 (85.75% PST). However, module 1 and 6 included questions on the same science process skills, PST had different true answering percentage in these modules. This can arise from that in the module 1, multiple choice questions including alternatives implying true answers and open ended questions in the module 6 require recalling and applying knowledge.

CONCLUSION AND RECOMMENDATIONS

As the data obtained from the questionnaire and the science process skills test were qualitatively and quantitatively examined, it is concluded that the majority of the PST could not comprehend the content of the science process skills due to not describing science process skills, confusing science process skills with Bloom's Taxonomy, problem solving and Piaget's Formal Operational Stage and not explaining the relationship between science and technology instruction program and science process skills. It is recommended that science process skills should be integrated to the science teacher training program effectively, PST should also be comprehended the relationship between science and technology instruction program and science process skills. It is also concluded that the majority of PST could not be aware of their own science process skills development due to the inconsistency between their statements in the questionnaire and their science process skills test results. 13 PST stated that experimenting skill was the most developed skill from their science process skills. However, it was found that the identifying variables and formulating hypotheses skills which were needed for experimenting had a low answering percentage of 9,38 in the open ended questions of module 6 in the science process skills test. On the other hand, PST had 73% of true answering percentage of the multiple choice questions examining the same skills of "the identifying variables and formulating hypotheses" in the module 1. When these different findings are considered, it revealed the importance of examination of PST' science process skills through multiple choice and open ended questions. 8 PST also stated that observing skill was the developed skill from their science process skills. In this study, multiple choice and open ended questions were used to collect data as a limitation. Therefore, PST' science process skills were not observed in a real application context. Thus, semi-structured observation forms should be used to check whether PST' observing skill is developed or not in further researches.

PST' statements revealed that science process skills are affected by different factors such as learning environment, personal attributes, phenomena, scientists' lives, models and activities, technology, daily life, experiments and documentary film and experience. Science teachers and instructors should use documentary films, daily life examples, models and activities, scientists' lives and technology for the acquisition of science process skills in physics, chemistry and especially biology courses. The rationale of this recommendation is that some PST stated the effectiveness of physics (20% PST) and chemistry (5% PST) and both (17.5% PST) but 2.5% of PST stated the effectiveness of biology course in science process skills development.

Even though some of the PST could explain science process skills theoretically, these PST had difficulty when transferring the theoretical knowledge into the practice. Beyond learning science process skills, to increase the awareness levels of PST' science process skills, appropriate learning environment and scales including multiple choice and open ended questions on the usage of science process skills should be prepared. PST should be encouraged to design some activities aiming to improve the development of science process skills of their students in future. Moreover, science education experts should prepare some example activities as a source.

In this study, an activity was developed to improve science process skills as an example. This example activity can be applied in physics course in science and technology instruction program and science teacher training program. Also, PST can use this example activity to prepare an activity aiming to develop science process skills. The information of the example activity on science process skills was presented in Table 6. The information explains the relationship with the example activity and science process skills. The example activity was given in Annex.

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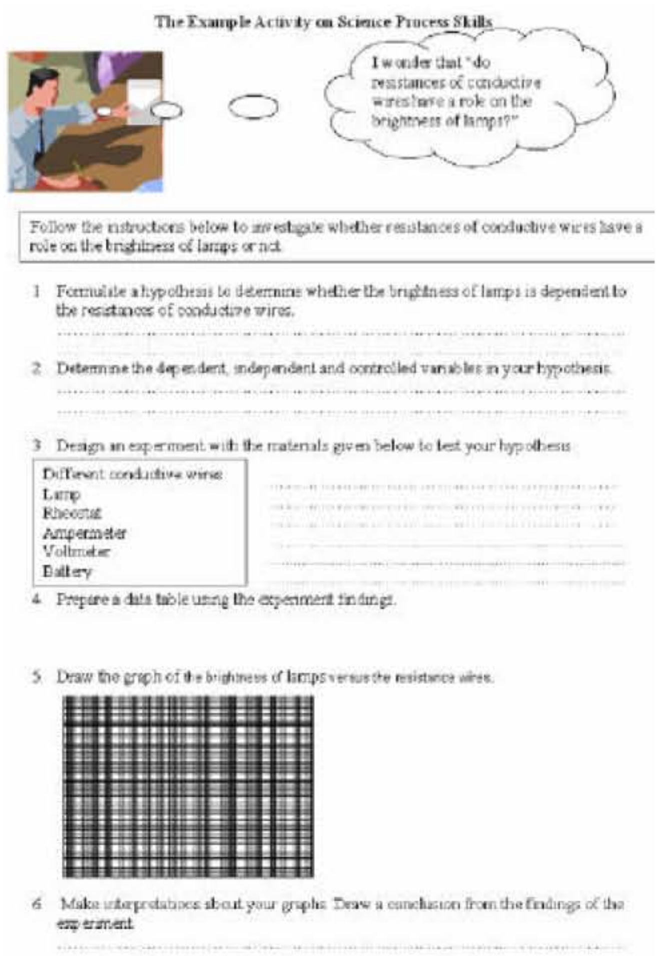
ANNEX



The Example Activity on Science Process Skills

I wonder that "do resistances of conductive wires have a role on the brightness of lamps?"

Follow the instructions below to investigate whether resistances of conductive wires have a role on the brightness of lamps or not.

1 Formulate a hypothesis to determine whether the brightness of lamps is dependent to the resistances of conductive wires.

2 Determine the dependent, independent and controlled variables in your hypothesis.

3 Design an experiment with the materials given below to test your hypothesis.

Different conductive wires
Lamp
Rheostat
Ampermeter
Voltmeter
Battery

4 Prepare a data table using the experiment findings.

5 Draw the graph of the brightness of lamps versus the resistance wires.

6 Make interpretations about your graphs. Draw a conclusion from the findings of the experiment.