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High School Science Teachers' Views on Science Process Skills

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The current research is a descriptive study in which a survey model was used. The research involved chemistry (n=26), physics (n=27), and biology (n=29) teachers working in Science High Schools and Anatolian High Schools in Turkey. An inventory that consisted of seven questions was designed to ascertain teachers' think about the importance of science process skills in teaching science, to identify the frequency of these skills and the problems teachers encounter during their practice in class, and to specify their identification levels on these skills. The results of the study showed that these skills in general have a positive effect on teaching science and that the in-class activities promote conceptual learning. Most of the teachers participated in the study argued that these skills can only be gained effectively through laboratory activities in which both teachers and students engage; and almost all of them thought that central-examination-based teaching poses a great obstacle. Teachers are more successful in identifying skills of observing, predicting, experimenting, and inferencing than other skills.

Keywords: science process skills, science education, science teachers.

INTRODUCTION

Science literacy has become a vital necessity for anyone living in a world full of scientific research with each passing day. Anyone who lives in this rapidly evolving world should be involved in the discussions about the important technological and scientific activities of society. Many tasks require advanced knowledge, skills, and productive communication with society. Science and scientific process skills contribute much to attaining these skills (Soylu, 2004). Padilla (1990) pointed out that, when scientific process skills are a specific planned outcome of a science programme, they can be learned better by students; therefore, teachers need to select curricula emphasizing scientific process skills. Developed western societies have considered scientific process skills as one of the most important part of curricula. In Turkey, there have been changes in the curricula intended to enhance the quality of chemistry, physics, and biology education. For the past a few years,

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scientific process skills have started to gain more importance in these secondary science education programmes.

In today's world where technology has been improving rapidly and attaining knowledge has become relatively easy, understanding the nature of science, producing scientific knowledge, suggesting and interpreting problems, and solving those problems as well as gaining knowledge should be the primary gains of students. Providing students with existing knowledge and making them acquire the ability to solve problems that are independent from everyday life will not be sufficient in order to prepare them for their future (Rillero, 1998). In this respect, the main goal of science education is to improve science literacy. To achieve this goal the principal objectives of the chemistry, physics, and biology curricula should be educate individuals who are able to understand the nature of scientific query, produce scientific knowledge applying scientific process skills, solve problems, employ scientific knowledge and methods in order to explain a case and apply them to new circumstances, provide justification for claims through evidence and proof, analyse and evaluate attained/current knowledge through experience, share scientific knowledge, and utilize information technology when required (Ministery of National Education [MONE], 2013a, 2013b, 2013c).

Teaching science involves the content and process components of science. Underestimating content over process or process over content is unacceptable, both is equally important. Content consists of subject matter and science concepts and process consists of esssential skills that students need to gain (Inan, 2010, 2011; Inan, Inan, & Aydemir, 2014). One of the primary skills that curricula aim for students to attain is science process skills. These skills have to be included not only in science course but also in all science related courses. According to Harlen (1999), science process skills are one of the major goals to be achieved in science education because these skills are utilized not only by scientists but also by everyone, in order to become scientifically literate people. Scientific process is a procedure essentially shaped by analytical and critical thinking skills (MONE, 2013a).

When classifications about science process skills are examined, there are two main skills: primary and integrated. *Primary skills* underlie science process skills and include observation, deduction and classification, measurement, prediction, using numbers, communication, and using space-time relations. *Integrated skills* are well-rounded and based upon primary process skills; they can be called experimental process skills because variables are specified, hypotheses are shaped, data are attained in order to prove or rebut them, data are recorded, and a judgement is reached. These processes pave the way for more questions to be asked and more experiments to be carried out (Kujawinski, 1997).

Science process skills are the tools that students use to investigate the world around them and to construct science concepts, so it is essential that teachers have a good understanding of these skills. Teachers need to employ and develop curricula that emphasize process rather than content in problem solving (Shaw, 1983). It is important that teachers' professional development integrates science content knowledge and science process skills carefully (Jeanpierre, Oberhauser, & Freeman, 2005). According to Wilks (as cited in Aybek, 2007), schools ought to make their teachers attain this knowledge so that they can educate students who question, participate more, are open to discussions, identify predictions and priorities, search for alternatives, and make sense of different views. Birman, Desimone, Porter, and Garet (2000) reported that ''the degree to which professional development focuses on content knowledge is directly related to teachers' increase in knowledge and skills'' (p. 30).

Findings of studies show that most science and technology, preschool, and preservice teachers are either not aware of or proficient in developing scientce process skills and that in-class activities do not specifically ensure that students attain these skills (Emereole, 2009; Luft, 2001; Mbewe, Chabalengula, & Mumba, 2010; Turkmen & Kandemir, 2011). Other studies have been conducted to establish the views and sufficiency of science and technology teachers and preservice teachers about science process skills in literature (Al-Rabaani, 2014; Emereole, 2009; Farsakoglu et al., 2008; Jeanpierre et al., 2005; Karslı, Sahin, Ayas, 2009). However, there are not adequate studies conducted with secondary science teachers (Sinan & Usak, 2011).

METHODS

In the current study, it is aimed to investigate the views of chemistry, physics, and biology teachers at Science High Schools and Anatolian High Schools in the city centers of Cankırı, Karabuk, Kastamonu, and Kutahya provinces of Turkey about the importance of science process skills in science education, how often they employ these skills in their class activities, the problems they encounter, and their skill identification levels. Hence, this is a descriptive research employing the correlational survey model.

Study group

In choosing the sample, a maximum-variability method of purposeful sampling was adopted that took the representation aptitude of the total field under survey into consideration; chemistry, physics, and biology teachers from two types of schools from four cities in three different geographical regions of Turkey (i.e., Western Black Sea, Central Anatolia, Aegean) were included in the sample. In this type of sampling, including different circumstances about the problem can give significant clues about the values of total field under survey (Büyüköztürk et al., 2008). Distribution and details of the participating teachers are given in Table 1.

In Turkey, middle school graduates are positioned in high schools according to the results of the Transition from Primary to Secondary Education (TPSE) examination. The students who receive the highest scores on TPSE exam are attending to mainly science and mathematics oriented science high schools, whereas the students who receive lower scores on the TPSE are attending to Anatolian high schools (AHS). Teachers are appointed to these schools according to their scores they receive from a national examination. It is imperative that teachers be experienced for at least three years in Ministry of National Education schools in order to be appointed to science or Anatolian high schools. Chemistry, physics, and biology classes are taught for four hours in a week, except for Grade 9 where science is taught for two hours in a week. In this study, the SHS teachers' experience ranged from 11–22 years and the AHS teachers from 4–18 years.

Table 1. Characteristics of the participants

School	**Subject taught**	**Central Anatolia**	**Western Black Sea**		**Aegean**	
		Çankırı	Karabük	Kastamonu	Kütahya	Total
Science high school	Chemistry	2	2	2	2	8
	Physics	3	3	3	2	11
	Biology	3	3	2	2	10
Anatolian high school	Chemistry	4	5	5	4	18
	Physics	3	4	4	5	16
	Biology	5	4	5	5	19

The aim of this study is to identify the science process skills (SPS) of secondary science (chemistry, physics, biology) teachers, determine their views about the attainment of these skills, and analyze their identification levels. The following research questions guided this study:

1. What are the views of physics, chemistry, and biology teachers about the importance of SPS on science education?
2. What are the views of physics, chemistry, and biology teachers about the role of SPS on concept learning?
3. What are the views of physics, chemistry, and biology teachers about the thinking types that SPS develop?
4. What are the views of physics, chemistry, and biology teachers about the environment in which SPS are attained?
5. What are the views of physics, chemistry, and biology teachers about the problems that are faced during the acquisition of SPS in curricula?
6. How often do they employ SPS during instruction?
7. What are their levels SPS identification?

Data collection tools

Teacher views inventory on SPS

An inventory was developed by the researcher for the purpose of establishing the SPS and opinions about the acquisition of these skills for secondary science teachers. The content validity of the inventory was ensured with the opinions of two experts of science education; the comprehensibility of the inventory items were tested through applying them to a chemistry teacher, a biology teacher, and two science and technology teachers who were doing their masters degrees in the Department of Science Education; and the inventory was finalized with a few adjustments. There were seven questions in the inventory. The first four were open ended. The fifth question presented 10 situations (crowded classrooms, insufficient time due to heavy schedule, inadequate skill development focus in textbooks, inadequacy of student levels, inadequacy of students' basic process skills, insufficient laboratories, insufficient in-class sample activities, negative attitude of students, central-examination-based teaching, and teachers' pedagogical field inadequacy in SPS) with a response choice of agree or disagree. The sixth question employed a 5-point Likert scale (always, once or twice a week, once or twice a month, once or twice a term, never) to identify how often teachers employed activities for students toward the acquisition of certain SPS (graphing, graph interpretation, inferring, hypothesizing, specifying, changing variables and keeping them stable, predicting, designing experiments, doing experiments, observating, measuring, data organization in graphs and tables, interpretation, conclusion, comparing, classification, visual-spatial thinking).

The first six questions in the inventory were about teachers' opinions on the impact of SPS on science education, concept learning and other thinking types, and the learning environments in which they were given; the difficulties they experienced while trying to make students attain these skills; and the frequency of the application of these skills. The last question was prepared to establish the teacher's identification level about these skills. Two scenarios were presented that included teacher-student dialogues. In the scenarios, a problem situation was given, then the teachers were asked which skills would improve in the environment that was built to solve the problem. Scenario 1 and Scenario 2 are given in Results section.

Data analysis

The primary idea behind the qualitative studies is to obtain information about participants' views on certain topics or issues and use best applications or analysis to gain the needed information (Budak & Budak, 2014). To learn about teachers'views on SPS in the sample, content analysis was carried out for tha data gathered through the inventory. First, in data analysis, the themes were identified in the form of words or sentences according to the research problem. Results were presented as frequencies after counting the phrases with regard to the specified themes.

RESULTS

Teachers' views about the importance of SPS in terms of science education

The teachers' answers to the question *"How significant are scientific process skills in terms of science teaching?"* were categorized as either significant or not significant. Results indicated that all the physics teachers thought that these skills have a positive effect on students' science learning and that 13% of the chemistry and biology teachers did not believe SPS have a significant effect on science learning. Table 2 displays the data analysis regarding teacher opinions.

The findings obtained from the categories that were formed by coding teacher answers were analyzed descriptively. Quotations from the views of the participants were directly given from time to time. The codings formed regarding the theme "positive effect of scientific process skills on science education" were identified as the following: learning, attitude, higher cognitive skills, self-efficacy, hands-on learning, scientific literacy. Figures 1 and 2 present the percentage of teachers based on codes with regard to their branches and examples of teacher perceptions are given.

Learning codes were formed regarding teacher opinions such as "they enable permanent learning," "they facilitate learning," "they eliminate rote learning," and "learning becomes easier." Attitude codes were formed regarding teacher opinions such as "positive attitude grows" and "science learning process develops positively." High cognitive skills codes were formed regarding teacher opinions such as "they improve thinking skills," "they foster different points of view to problems," "they enable students to discover the answers to questions why-how, query," and "interpretation." Self-sufficacy codes were formed regarding teacher opinions such as "self-confidence" and "courage." Hands-on learning codes were formed regarding teacher opinions such as "learning through experience," "since they are practical," and "the gained experience is visual." Science literacy codes were formed regarding teacher opinions such as "application of knowledge" and "learning how to catch fish." The percentage of SHS teachers for the categories and Figure 1 and examples of their responses for each category are given in Table 3.

Table 2. Teacher opinions about the significance of SPS in terms of science teaching

School	Subject taught	Significant (*f*)	Not significant (*f*)
Science high school	Chemistry	6	2
	Physics	11	-
	Biology	8	2
Anatolian high school	Chemistry	17	1
	Physics	16	-
	Biology	14	5

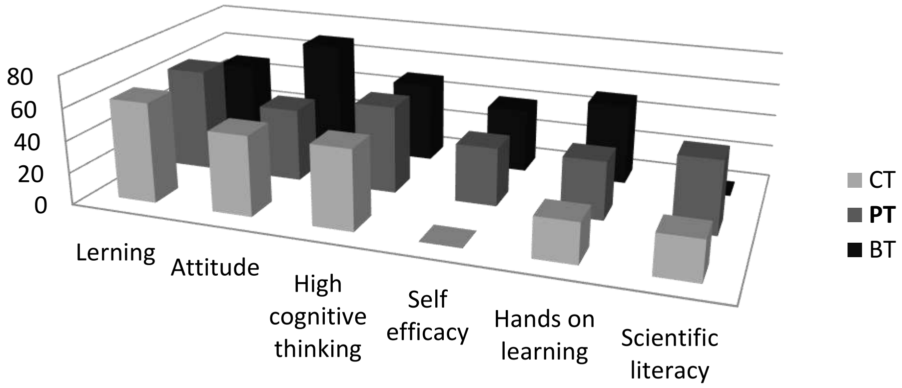

Figure 1. Percentage of science high school teachers' views about the importance of SPS in terms of science education; CT = chemistry teachers, PT = physics teachers, BT = biology teachers.

Table 3. Percentage of science high school teachers for the categories about the importance of SPS in terms of science education and response examples

Code	CT %	PT %	BT %	Examples of science high school (SHS) teachers' responses
Learning	63	65	50	SHS_PT3(16)*: *...learning becomes easier excluding memorization.* SHS_CT1(22): *... facilitate learning and enable permanent learning.*
Attitude	50	45	70	SHS_CT3 (26), SL_BT1(12): *... SPS have a positive effect on science classes.*
High cognitive thinking	50	55	50	SHS_CT2(14): *... actively engage in inquiry and make inference. ... scientific reasoning, decision making..* SHS_PT3(16): *...interpret the result of experiment by inductive and ... use inductive reasoning.*
Self-efficacy	0	36	40	SHS_PT1(17)*: Students break out of laziness. ..develop self-confidence.*
Hands-on learning	25	36	50	SHS_BT1(12): *...promote permanent learning. Because they contain hands-on learning.*
Scientific literacy	25	45	0	SHS_CT2(14): *... everyday life skills. ...connect life and school.* SHS_PT2(19): *Intense background knowledge complicates the transfer of all knowledge. ... help students learn how to catch fish.*

*School type_Branch of teacher (experience year)

The percentage of AHS teachers for the categories and Figure 2 and examples of their responses for each category are given in Table 4.

It can be viewed that most SHS and AHS physics teachers held the view that SPS promoted higher cognitive thinking skills while fewer biology teachers believed that SPS had a positive effect on higher cognitive thinking skills. All of the physics teachers indicated that SPS had a positive effect on science teaching whereas two biology and two chemistry SHS teachers and five biology AHS teachers argued that SPS had no effect on science education. Quotations from teacher opinions follow.

SHS_CT4(15): *... do not believe in the significance of SPS in science teaching at high schools.*

SHS_BT4(23): *... do not believe in the significance of SPS in science teaching. ... do not think coursebooks and curricula are prepared in order to promote SPS. ... do not think that they have so-called effects on science learning, enjoying science classes, high performance in science classes.*

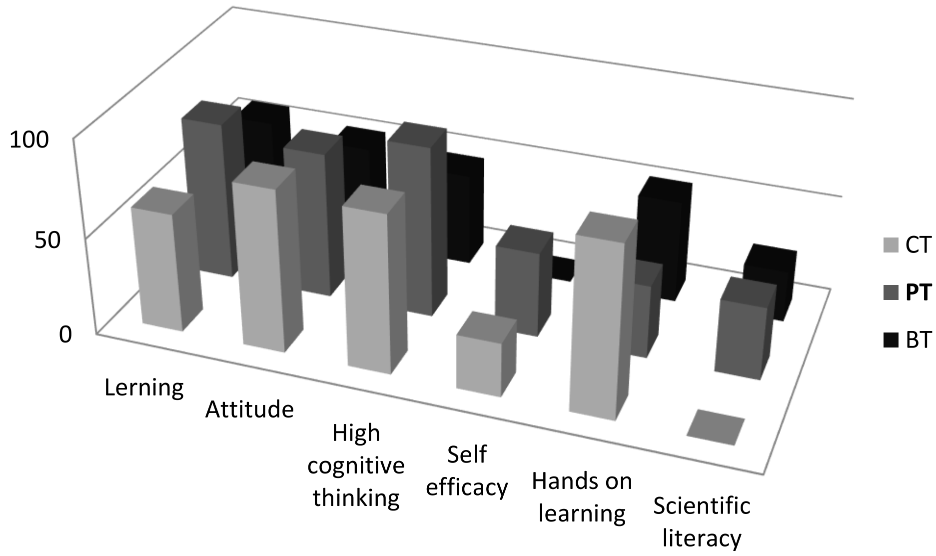

Figure 2. Percentage of Anatolian high schoolteachers' views about the importance of SPS in terms of science education; CT = chemistry teachers, PT = physics teachers, BT = biology teachers.

Teachers' opinions about the role of SPS in concept learning

Teachers' answers to the question *"Do SPS effect concept learning? If yes, how?"* formed two codes: Activities toward SPS attainment promote or hinder concept learning. When the data were analyzed, it was found that all of the physics teachers in both types of schools argued that SPS promoted concept learning and that mostly biology teachers (20% SHS and 36% AHS) and 25% of chemistry SHS teachers argued that they hindered concept learning. When the favourable answers of the teachers are analyzed, it can be seen that on the whole they attached great importance to concept teaching; and they argued that SPS promoted concept learning, that students moved away from rote learning as a consequence of hands-on learning through practices intended for the attainment of these skills, and hence, they were able to construct relations between concepts. Below are some teacher opinions about the promotion of SPS on concept learning.

Table 4. Percentage of Anatolian high school teachers for the categories about the importance of SPS in terms of science education and response examples

Code	CT %	PT %	BT %	Examples of Anatolian High School (AHS) teachers' responses
Learning	61	81	58	AHS_CT2(11)*: *... enhance productivity and hamper rote learning.* AHS_PT3(8): *... significant for active, purposeful, and easy learning.*
Attitude	83	75	53	AHS_PT3(8): *...they develop a positive attitude.* AHS_BT3(10): *It makes science classes more enjoyable. However, every step of the application has to be interpreted.*
High cognitive thinking	81	88	47	AHS_CT1(17): *SPS ... based on building cause-effect relationship, recognizing tools, generalizing through interpretation, ... deductive and inductive reasoning.*
Self-efficacy	28	44	0	AHS_PT5(13): *...motivates and encourages students. This way they solve problems more strategically*
Hands-on learning	88	38	53	AHS_BT3(10): *Experimenting is essential for visual intelligence. It also provides active participation.*
Scientific literacy	0	38	26	AHS_PT4(18): *...SPS enable students to know how to reach knowledge.* AHS_BT1(25): *...an efficient role in providing a basis in students' scientific thinking, being scientifically literate people*

**School type_Branch of teacher (experience year)*

SHS_BT2(15): *I care about SPS as much as concept learning. … realize that concept learning of students enhances. For instance, tenth grade students have difficulty in graph questions. As practices on graphing and graph interpretation increase, they acquire deeper learning.*

AHS_CT3(23): *…are substantial before or after concept learning occurs. SPS are not beyond concept learning but next to it. The ways to obtain knowledge varies for each student. Some learn visually while others learn theoretically. If concepts are learned together with SPS, learning becomes easier, more effective, and more permanent. They provide learning without memorizing.*

Teachers who believed that SPS hindered concept learning argued that SPS practices caused time loss. The responses of these teachers follow.

SHS_CT4(15): *students need to learn the concepts correctly and permanently. In order to achieve this, SPS are not a must. Concepts can be taught theoretically.*

AHS_BT4(18): *I do not believe that SPS have an efficient role in concept learning or concept improvement; on the contrary, such activities complicate concept learning. For example, when you experiment, it is just a demonstration for students.*

Teachers' view about thinking types that they believe SPS are effective on

With the teachers' answers to the question "*Do scientific process skills contribute to improving other thinking types for students? If yes, what thinking types are they effective on?*", codes of analytical thinking, critical thinking, problem solving, scientific thinking, and creative thinking were formed. Figures 3 and 4 show that more biology teachers, compared with other science teachers in both types of schools, argued that SPS helped improve scientific thinking, problem solving, and creative thinking (except AHS). SHS biology teachers mainly believed that SPS helped develop problem-solving skills, chemistry and physics teachers thought that they contributed to scientific thinking skills whereas AHS biology and physics teachers argued that they helped improve scientific thinking skills and chemistry teachers thought that they helped develop critical and scientific thinking skills. The fewest number of teachers in both school types related creative thinking skills with SPS compared with other skill types. Two SHS teachers argued that SPS helped improve scientific thinking skills.

Opinions of five secondary education teachers about the hindrance of SPS on other thinking skills follow.

SHS_BT4(23) & SHS_CT4(15): *I do not believe that SPS contribute to the improvement of other thinking skills; as a matter of fact, I think they are a barrier as they move systematically.*

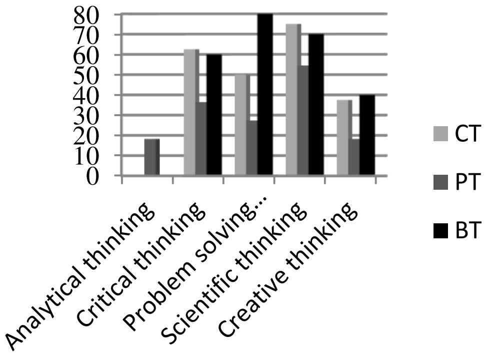

Figure 3. Percentage of SHS teachers' view about thinking types that SPS improve

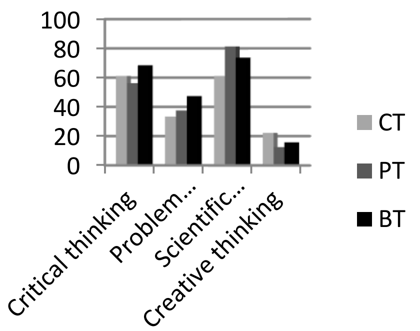

Figure 4. Percentage of AHS teachers' view about thinking types that SPS improve

AHS_BT4(18): *They are the barriers of critical thinking, acquiring alternative point of views in problem solving and reasoning skills.*

Teachers' views about the learning environment in which SPS are acquired

In response to the question *"In what learning environment do scientific process skills improve most effectively?"* the teachers said that this depended on the active participation of students and teachers and classrooms (laboratories or classrooms). It was established that all of the teachers adopted a teacher-centered approach but they had different opinions about the active participation of students and teachers in order for SPS to be effective. For this question, the following codes were formed: teacher is active, students are active, and teacher and students are active. The findings obtained from teacher opinions about this issue are presented in Figures 5 and 6.

When Figures 5 and 6 are examined, it can be seen that more than 50% of physics and biology teachers of both types of schools and chemistry teachers argued that students could acquire SPS effectively in atmospheres where students and teachers were involved actively, whereas 50% of SHS chemistry teachers held the view that efficient acquisition could occur only when teachers participated actively. Teachers' opinions about the acquisition of SPS regarding classrooms were coded as only in laboratories, in laboratories and classrooms, or with computer simulations. Frequencies of the codings are presented below (Figures 7 & 8).

When Figures 7 and 8 are viewed, it can be seen that more than 50% of secondary education science teachers argued that SPS could be acquired best in a computer environment and ~20% of them believed that they could be attained best in a laboratory environment. Samples of teacher opinions follow.

SHS_CT6(19): *SPS can efficiently be attained in laboratory environment where teachers are active. However, students should definitely be asked about their interpretations at the end of the experiment. As our laboratories are not spacious, I do demonstration experiments. I cannot have my students carry out experiments by themselves actively. They are just viewers. .... There are wonderful simulations on the Internet. I certainly have them watch simulations about topics such as gases, chemical equations, and electrochemistry.*

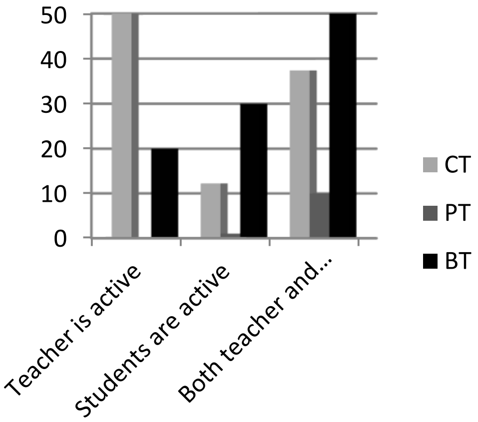

Figure 5. SHS teachers' view about learning environment in which SPS are acquired regarding the active participation of students and teachers.

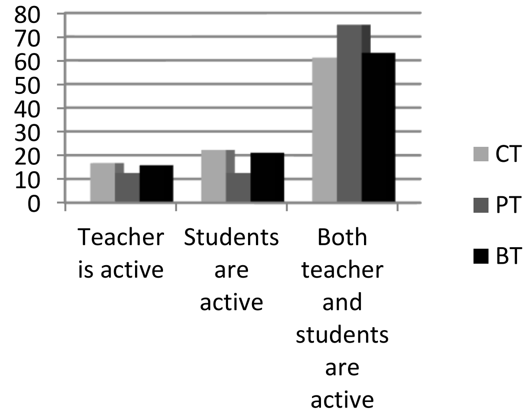

Figure 6. AHS teachers' view about learning environment in which SPS are acquired regarding the active participation of students and teachers.

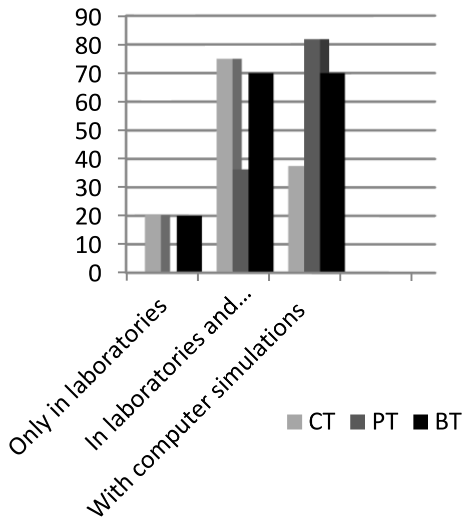

Figure 7. SHS teachers' views about the environment in which SPS are acquired regarding classroom conditions

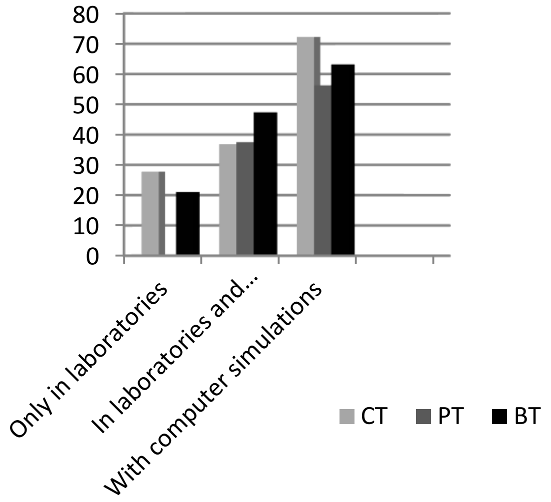

Figure 8. AHS teachers' views about the environment in which SPS are acquired regarding classroom conditions

AHS_CT6(10): *SPS can be explained in the classroom and then they can be consolidated through experiments. SPS can be taught during science and mathematics classes.*

AHS_CT3(8): *Effective teaching takes place in labs with traditional approaches. It is even possible to make students acquire SPS in every class. …observation, classification, prediction can be carried out in geography classes. They can be improved in mathematics classes even in literature classes.*

Teachers' views about the problems confronted while having students attain SPS within the context of curricula

This question specified 10 possible problems confronting teachers while teaching SPS; response options were "I agree" or "I do not agree". They stated the following problems they face with: Crowded classrooms, lack of time due to intensive programme, insufficient focus of coursebooks on skill development, inadequate background student knowledge, insufficient students on basic process skills, lack of laboratories, insufficient in-class activities, negative attitudes of students toward science, teaching focusing on national-examination system, and insufficient use of teachers' pedagogical methods on SPS. Frequencies regarding teacher opinions are given in Figures 9 and 10.

All of the teachers indicated that intense curricula and the central-examination-focused education system were the problems confronted during the acquisition of SPS. Over 50% of SHS teachers expressed that they faced all the problems except for student insufficiency and negative attitude of students. Over 50% of AL physics, chemistry, and biology teachers expressed that they faced all of the problems mentioned above. All of the teachers thought that lack of time due to intense programme and central-examination-focused eduacation were the barriers to SPS attainment.

Frequency of practices toward the improvement of SPS

The results to the question regarding the frequency of teachers' practice toward the attainment of SPS within a school term with five response options (i.e., always, once or twice a week, once or twice a month, once or twice a term, never) are presented next. Data belonging to SHS teachers are given in Table 5 and to AHS teachers are given in Table 6.

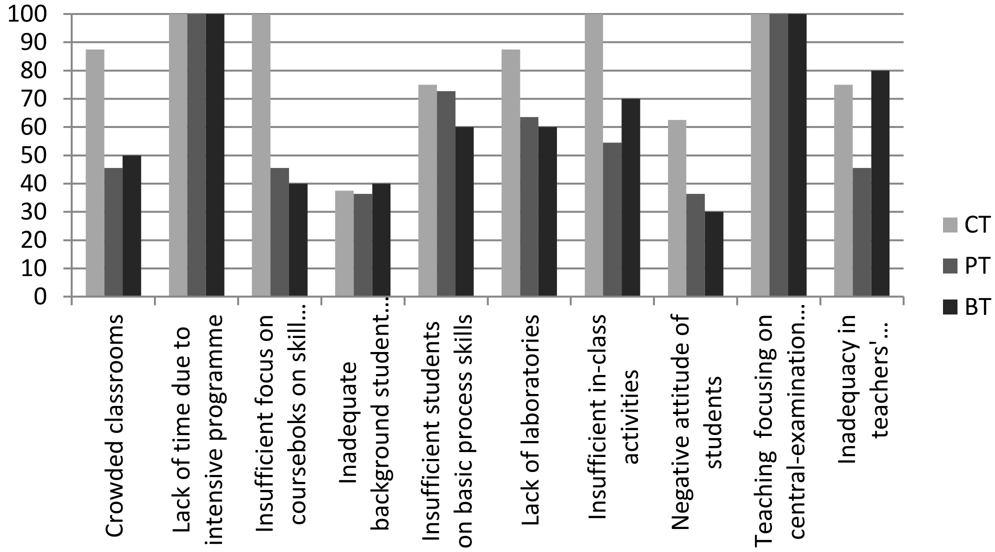

Figure 9. Science high school teachers' view about the problems confronted while having students attain SPS

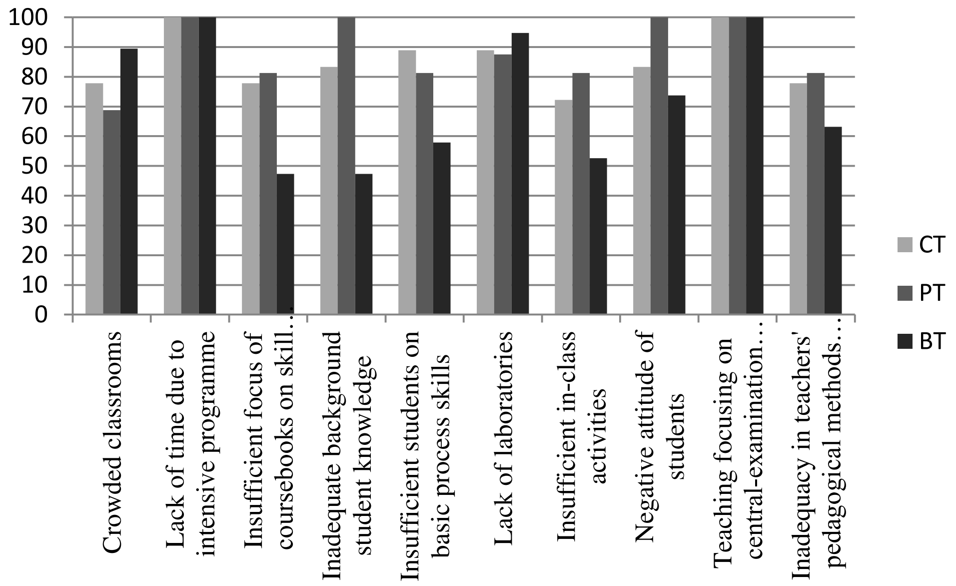

Figure 10. Anatolian teachers' view about the problems confronted while having students attain SPS.

More than 50% of SHS teachers stated that they never had students design an experiment; a few of them (chemistry: 13%, physics: 18%, biology: 40%) expressed that they did this once or twice a semester. About 18% of physics, 25% of chemistry, and 10% of biology teachers stated that they had students draw graphs or tables making use of data obtained once or twice a term. Most of the teachers indicated that they performed SPS-skill-attainment activities during the experimentation stage once or twice a school term. More than 50% of all SHS teachers stated that they practised graphing, inferring, identifying variables and keeping them constant, prediction, interpreting, conclusion, comparing, thinking visually and spatially skills at least once or twice a week; however, only 25% of chemistry teachers stated that they rarely practised observation, and only 18% of physics teachers indicated that they rarely practised classification. More than 50% of the teachers in the sample stated they practiced hypothesizing once or twice a term.

Table 5. Percentage of SHS teachers in practicing of SPS

SPS	Teachers	Frequency (%)				
		Never	1–2 term	1–2 month	1–2 week	Always
Graph drawing	CT	0	13	25	63	0
	PT	0	9	27	64	0
	BT	0	10	30	60	0
Graph interpreting	CT	0	0	25	75	0
	PT	0	27	9	64	0
	BT	0	0	40	60	0
Inferring	CT	0	0	13	75	13
	PT	0	18	9	55	18
	BT	0	20	10	60	10
Hypothesizing	CT	0	63	13	25	0
	PT	0	55	27	18	0
	BT	0	60	20	20	0
Identifying–changing-keeping constant variables	CT	0	0	13	63	13
	PT	0	9	27	45	18
	BT	0	10	20	60	10
Prediction	CT	0	0	13	25	63
	PT	9	18	9	36	18
	BT	0	20	20	50	10
Designing an experiment	CT	88	13	0	0	0
	PT	82	18	0	0	0
	BT	60	30	10	0	0
Doing experiment	CT	25	38	38	0	0
	PT	36	55	9	0	0
	BT	20	70	10	0	0
Observing	CT	0	25	37	25	0
	PT	0	0	21	36	27
	BT	0	5	50	15	10
Measuring	CT	25	38	38	0	0
	PT	27	55	18	0	0
	BT	40	50	10	0	0
Drawing graphs or tables making use of data	CT	50	25	0	0	0
	PT	73	27	0	0	0
	BT	90	10	0	0	0
Interpreting	CT	0	0	0	25	75
	PT	0	0	18	55	27
	BT	0	0	10	40	50
Concluding	CT	0	0	0	25	75
	PT	0	0	9	45	45
	BT	0	0	10	50	40
Comparing	CT	0	0	0	25	75
	PT	0	0	18	55	27
	BT	10	0	20	50	30
Classifying	CT	0	13	25	63	0
	PT	0	18	54	27	0
	BT	0	0	20	60	20
Thinking visually and spatially	CT	0	0	13	63	25
	PT	0	27	9	36	27
	BT	0	10	20	30	40

Table 6. Percentage of AL teachers in practicing of SPS

SPS	Teachers	Frequency (%)				
		Never	1–2 term	1–2 month	1–2 week	Always
Graph drawing	CT	0	17	39	56	0
	PT	0	19	44	38	0
	BT	0	16	84	0	0
Graph interpreting	CT	0	6	28	61	6
	PT	0	0	19	81	0
	BT	0	11	68	21	0
Inferring	CT	0	11	11	56	22
	PT	0	19	13	69	0
	BT	0	11	37	53	0
Hypothesizing	CT	0	6	11	72	11
	PT	0	25	19	56	0
	BT	0	5	63	32	0
Identifying–changing-keeping constant variables	CT	0	6	72	22	0
	PT	0	19	69	12	0
	BT	0	58	26	16	0
Predicting	CT	0	0	22	61	17
	PT	0	6	25	69	0
	BT	0	11	21	68	0
Designing an experiment	CT	83	6	0	0	0
	PT	100	0	0	0	0
	BT	84	16	0	0	0
Doing experiment	CT	6	17	61	17	0
	PT	25	69	6	0	0
	BT	0	11	26	47	16
Observing	CT	0	17	28	44	11
	PT	0	12	19	56	0
	BT	0	11	11	79	0
Measuring	CT	0	17	67	17	0
	PT	6	37	50	6	0
	BT	0	58	42	0	0
Drawing graphs or tables making use of data	CT	89	11	0	0	0
	PT	81	19	0	0	0
	BT	90	11	0	0	0
Interpreting	CT	0	0	22	44	33
	PT	0	6	37	50	6
	BT	0	5	16	63	16
Concluding	CT	0	0	17	44	28
	PT	0	0	19	50	31
	BT	0	0	11	47	42
Comparing	CT	0	0	17	33	50
	PT	0	0	31	44	25
	BT	0	0	11	47	42
Classifying	CT	0	22	50	17	0
	PT	6	19	62	12	0
	BT	0	5	16	53	26
Thinking visually and spatially	CT	0	0	44	50	6
	PT	6	19	50	31	0
	BT	0	5	58	11	26

Most of the AL teachers (<50%) never had their students design experiments or transfer experimental data in the graph; yet, 6% of chemistry and 16% of biology teachers stated that they had their students design experiments; and 11% of chemistry, 11% of biology, and 19% of physics teachers expressed that they had their students transfer experimental data in the graph once or twice a term. Teachers performed graph interpreting more often than graph drawing. Findings obtained from data showed that more than 50% of the teachers included interpreting, inferring, and comparison practices at least once or twice a week in their classes. Most physics and chemistry teachers frequently included specifying and changing variables and keeping them constant practices in their classes; most biology teachers included classification practices in their classes. Another interesting finding is that only SHS chemistry and physics teachers scarcely performed observation skill practices yet other teachers frequently did that. When we take this into consideration, that 25% or 37% of SHS chemistry teachers utilized laboratories and computer environment and more than 50% utilized classrooms for SPS development could be an indicator that they practised these skills through questions/problems.

How teachers identify SPS

In question 7, two different scenarios were given for the purpose of specifying the teachers' SPS identification level. A problem situation was presented in the manner of teacher-student dialogue. Teachers were required to identify SPS through the expressions in the dialogues. Scenario 1 and examples of SPS that teachers identified follow.

SCENARIO 1

Sibel notices that different types of fish in the aquarium are sometimes quite mobile and at other times are quite calm. She asks her teacher the reason for the change in the mobility of different kinds of fish. The teacher tells Sibel that she can find the answer on her own and assigns her this topic as a research project. In an effort to guide her, the teacher reminds her to bear in mind the changes in the outer environment and the motion of the fish with regard to those changes; to recall what causes changes in the mobility of the fish making connections; to regularly follow the changes of mobility of each fish making controlled alterations in each factor she identifies in order to obtain a clear-cut answer; to record each and every stage; to write down her expectations before each practice and compare her expectations with the findings in the end. What scientific process skills does the teacher intend to improve through the research Sibel is to carry out?

SPS	Teachers' responses
Observing	*Sibel notices that different types of fish are sometimes quite mobile and at other times are quite calm…* *… to regularly follow each step at regular intervals through the end of the application…* *Along experiment she would have observed.*
Classifying	*…follow each step at regular intervals through the end of the application…* *… different types of fish are sometimes quite mobile and quite calm at other times …*
Measuring	*… the changes in the outer environment in an effort to guide her …* *… the changes in the motion of each fish after each alteration…* *… to follow each stage regularly…*
Predicting	*… in an effort to guide her, the teacher reminds her to bear in mind the changes in the outer environment and the motion of the fish with regard to those changes; to recall what causes*

	changes in the mobility of the fish making connections… *… her expectation about the changes of mobility of each fish through alterations in each factor …*
Specifying and changing variables and keeping them constant	*… the outer environment to guide her…* *… what factor causes what changes in the mobility of fish …* *… notices that different types of fish in the aquarium are sometimes quite mobile and quite calm at other times. …asks her teacher the reason for the change in the mobility of different kind of fish …* ***…** to compare her expectations with the findings …* *… to note down her expectations before each practice …* *… to regularly follow the changes of mobility of each fish making controlled alterations in each factor that she identifies in order to obtain a clear-cut answer ...*
Doing experiment	*… to regularly follow the changes in the mobility of each fish making controlled alterations in each factor that she identifies in order to obtain a clear-cut answer, to record each and every stage…*
Designing experiment	*... she wants her to regularly follow the changes of mobility of each fish making controlled alterations in each factor that she identifies in order to obtain a clear-cut answer, to record each and every stage, to note down her expectations before each practise and compare her expectations with the findings.*
Interpreting	*... to recall what causes changes in the mobility of the fish making connections...*
Concluding	*… the findings…* *… in a controlled manner in order to obtain a clear-cut answer …*
Data recording	*… to record each and every stage …*
Comparing	*… compare her expectations with the findings …* *… that different types of fish are sometimes quite mobile and quite calm at other times…* *… in the mobility of each fish…to compare…*
Inferring	*… to recall what causes changes in the mobility of the fishmaking connections …*

The scientific process skills that teachers identified in Scenario 1 are given in

Table 7. Percentage of teachers in terms of identifying SPS in Scenario 1

	Science High School			**Anatolian High School**		
	Chemistry	Physics	Biology	Chemistry	Physics	Biology
Observing	All					
Classifying	50	27	60	39	25	58
Measuring	25	9	30	22	13	26
Predicting	50	64	60	61	56	53
Specifying and changing variables and keeping them constant	50	27	30	39	25	16
Data recording	100	82	90	100	94	100
Concluding	88	45	60	61	44	47
Doing experiment	All					
Designing experiments	50	9	20	17	-	11
Interpreting	38	18	30	28	44	42
Comparing	100	91	90	100	81	100
İnferring	-	-	10	-	6	-

Scenario 2 and the scientific process skills that teachers identified follow.

SCENARIO 2

Ayşe learns in a chemistry class that if a surface area is lessened, reaction will speed up and recalls that her mother is quicker in placing ground meat in the deep freezer than meat in small chunks in Feasts of Sacrifice. She asks her teacher if this behaviour can be an example of this chemical event. The teachers asks Ayşe why her mother behaves that way and Ayşe shares her opinion, making associations. The teacher tells her to explore the validity of her answer with her classmates through simple trials once she brings necessary equipment. She realizes that the findings as a result of the applications she carries out with her mates and the assistance of her teacher support her teacher's answers to her previous questions. What scientific process skills does Ayşe employ?

SPS	Teachers' Responses
Observing	*… that her mother is quicker in placing ground meat in the deep freezer than meat in small chunks in Feasts of Sacrifice …* *… as a result of the applications she carries out with the assistance of her teacher …* *… as a result of the applications …* *She observes that ground meat spoils faster* *She may have seen that ground meat spoiled faster than meat in chunks*
Classifying	*… the ground meat than meat in chunks…* *... recalls that her mother is quicker in placing ground meat in the deep freezer than meat in small chunks in Feasts of Sacrifice …(she classifies if it is related or not)*
Measuring	*… that her mother is quicker in placing in the deep freezer …* *… the applications she carries out …* *Temperature of the room can be measured* *Meat in chunks and ground meat (particle size)*
Predicting	*… if this behaviour can be an example … predicting that ground meat spoils faster* *… Ayşe shares her opinion making associations …*
Specifying and changing variables and keeping them constant	*… recalls that her mother is quicker in placing ground meat in the deep freezer than meat in small chunks. She asks her teacher if this behaviour can be an example …* *... through simple trials ...* *Duration of spoilage of ground meat and meat in chunks (surface area) at the same temperature* *Different surface area, same temperature*
Doing experiment	*… as a result of the applications she carries out with her mates and the assistance of her teacher …*
Designing experiment	*She determines the equipment and how to interpret it by herself.* *… She realizes that the findings as a result of the applications she carries out with her mates and the assistance of her teacher support her teacher's answers to her previous questions …*
Interpreting	*… her opinion making associations..*
Concluding	*… ground meat should be placed in the deep freezer earlier …* *At the end of the experiment she understands the subject and proves the accuracy of the example she has given.* *… She realizes that the findings as a result of the applications she carries out with her mates and the assistance of her teacher*

	support her teacher's answers to her previous questions.
Comparing	*… that her mother is quicker in placing ground meat in the deep freezer than meat in small chunks …*
	Ground meat spoils faster.
Hypothesizing	*Ayşe shares her opinion making associations: Ground meat spoils faster than meat in chunks.*
	… the validity of Ayşe's answer…
Inferring	*… if surface area is lessened, reaction will speed up and recalls that her mother is quicker in placing ground meat in the deep freezer than meat in small chunks in Feasts of Sacrifice …*
	and Ayşe shares her opinion making associations.
Functional identifying	*Particle size*

The scientific process skills that teachers identified in Scenario 2 are provided in Table 8.

This part of the research presents, the findings obtained from the results of the SPS that teachers identified from the statements in the scenarios. All of the teachers identified observation skills through correct statements in Scenario 1 whereas all, except for two physics teachers, of the AL teachers identified observation skills through correct statements in Scenario 2. Few teachers, mostly biology teachers, identified the statement, "different types of fish are sometimes quite mobile and quite calm at other times" correctly as classification in Scenario 1. The "recalls that her mother is quicker in placing ground meat in the deep freezer than meat in small chunks in Feasts of Sacrifice (she classifies if it is related or not)" statement in Scenario 2 was identified differently and incorrectly as classification skills by two AL physics teachers. It was observed that biology teachers were better at identifying classification skills. A reason for this may be that they practiced these skills a lot in in-class and assessment activities. The "changes in outer environment" statement in Scenario 1 could have indirectly been identified as measurement (e.g., temperature of water, how often the fish are fed) skills. Few teachers thought that this could indicate measurement skills. Biology and chemistry teachers outnumbered physics teachers in identifying this statement as measurement skills.

Table 8. Percentage of teachers in terms of identifying SPS in Scenario 2

	Science High School			**Anatolian High School**		
	Chemistry	Physics	Biology	Chemistry	Physics	Biology
Observing		All		88		All
Classifying	-	-	-	6	13	-
Measuring	50	18	10	17	6	16
Predicting	50	45	40	39	44	32
Specifying and changing variables and keeping them constant	50	36	30	11	6	-
Doing experiment	88	100	90	94	100	89
Designing experiment	13	-	10	6	-	-
Interpreting	38	18	40	44	38	47
Concluding	88	73	70	61	56	68
Comparing	100	91	100	100	100	89
Hypothesizing	13	-	10	-	-	-
Inferring	13	-	20	-	6	-
Functional identifying	13	-	-	-	-	-

Because most teachers could not find clear-cut statements about measuring the changes in variables in both scenarios, few teachers were able to identify measurement skills. That two teachers stated, "There are no clear-cut statements concerning measurement" can be an indicator of their unidentification due to the indirect speech. That 50% of the teachers or more in every branch did not allow enough time for improving measurement skills can be a reason for this result. One SHS and one AL teacher pointed out the statement *"to recall what causes changes in the mobility of the fish making connections"* in Scenario 1 for identifying inferring skills. More than 50% of the teachers identified this statement as prediction skills and 25–30% of the teachers identified this statement as interpretation skills. Five teachers in total identified the statements *"when she learns in a chemistry class that if surface area is lessened, reaction will speed up she recalls that her mother is quicker in placing ground meat in the deep freeze than meat in small chunks"* and *"Ayşe shares her opinion making associations"* as inferring skills in Scenario 2. Two SHS physics teachers and 40% of other teachers identified the second statement as interpretation skills. Although teachers expressed that they practised inference skills activities once or twice a week or month to improve these skills in their students, only 5% of the teachers were able to identify these skills. More teachers could identify the skill of specifying and changing variables and keeping them constant in Scenario 1 than in Scenario 2, and chemistry teachers were better at this.

AL biology teachers left dependent variables out and identified only the independent variable when they identified the statement *"In an effort to guide her … the changes in the outer environment"* as specifying variables and excluded the rest of the sentence. It is presumptive that the SHS biology teacher thought that the character in Scenario 1 compares her prediction before the application and the findings she obtains after the application about the effect of the independent variable on dependent variable when he/she identified the statement *"comparing her expectations and the findings"* as the skill of specifying and changing variables and keeping them constant. It was observed that mainly chemistry teachers (three SHS and one AL) identified the statements *"what causes changes in the mobility of the fish"* and "*… of each fish … alterations in each factor"* in Scenario 1 and the statements *"duration of spoilage of ground meat and meat in chunks (surface area) at the same temperature"* and *"different surface are, same temperature"* in Scenario 2 as the skill of specifying and changing variables and keeping them constant. It can be said that teachers indirectly identified the skill of specifying and changing variables from the statement *"through simple trials"* in Scenario 2. All of the teachers in Scenario 1 and more than 85% of the teachers in Scenario 2 identified experimenting skills with correct statements. Mainly chemistry teachers were able to identify the skill of designing experiment in Scenario 1, and three teachers could identify it correctly in Scenario 2. Given the fact that the teachers stated they never had their students design experiments, the result is not surprising. It was observed that more than 50% of the teachers could identify inference skills correctly, that SHS teachers were better at identifying these skills than AL teachers, and that chemistry teachers were better at identifying these skills than other teachers. More than 50% of SHS teachers and AL physics teachers identified data recording skill with the correct statement in Scenario 1. Approximately 90% of all teachers in the study could identify comparison skills with the correct statement. One SHS chemistry teacher was able to identify hypothesizing and functional identification skills with the correct statement.

DISCUSSION AND CONCLUSION

Most teachers (all physics teachers) had the opinion that scientific process skills had a positive effect on science education, whereas 10% of them (mainly biology teachers) did not believe in that significant effect. Yıldırım, Atilla, Özmen, & Sözbilir (2013). inferred from their study with preservice science teachers that some teachers did not possess sufficient SPS knowledge in science education and some did not deliver any opinions about it. Physics, chemistry and biology teachers expressed that SPS had positive effects on science education in terms of learning, attitude, higher thinking, self-efficacy, and practice; more than 50% of all teachers held the view that SPS backed up permanent learning without rote learning and supported higher thinking skills. In the three science disciplines included in this study, there were teachers who had the opinion that SPS had positive effects on inquiry and discovery skills, mainly on reasoning skills. Another remarkable point is that physics teachers, when compared with both AHS and SHS chemistry and biology teachers, presented more comprehensive opinions about the effect of SPS on science education.

All of the physics teachers and most of the other teachers argued that SPS supported concept learning; however, several teachers thought that these skills hindered concept learning. The opinions of the teachers gave us the clue that virtually all of them prioritized concept learning. The activities they performed in classes were intended to enhance concept learning, not particularly the attainment of SPS by students. Once again, physics teachers had better awareness levels than other teachers in terms of SPS teaching. Ten teachers claimed that SPS had no effect on or hindered concept learning; they found SPS a great waste of time in the current education system and argued that teaching concept knowledge theoretically could be possible and sufficient. A teacher at Anatolian high school supported that idea through a student's report statement, *"Bommm! Pufff! Pısss!"* According to Işık and Nakiboglu (2011), teachers are not adequately informed about what is suggested in teaching programmes about the teaching of SPS along with concepts.

Five categories were formed in accordance with the opinions of the teachers about the types of thinking that SPS develop: critical thinking, analytical thinking, problem solving, scientific thinking, and creative thinking. It can be viewed that biology teachers possessed a higher awareness level compared with other teachers in terms of the effects of SPS on other thinking types. In particular, SHS biology teachers believed that SPS improved problem-solving skills while other teachers in both types of schools remained incapable of relating SPS and problem-solving skills. Moreover, fewer teachers related SPS with creative thinking skills than other thinking types. In addition, two SHS physics teachers mentioned analytical thinking skills. Five teachers argued that SPS proceeded systematically and, hence, hindered skills such as critical thinking and reasoning. Teachers fell surprisingly behind in relating SPS with other thinking types and in skill development as they passively employed SPS in concept teaching without being aware of and recognizing the attainments about these skills in curricula.

When the teachers' opinions about what environments could be most effective in order to develop SPS are viewed, most of them, mainly physics teachers, thought ready-made programmes on the Internet would be effective. Türkmen and Kandemir (2011) argued that, if students actively participate in the experiments, it would be useful in learning whereas, if it was a demonstration experiment during which students were only viewers, sufficient learning would not occur and it would even be a waste of time. Inan and Inan (2015) state that opportunities for manipulation, play, teacher support, and enriched activities help students be more hands-on, minds-on, and hearts-on. In current study physics teachers in both types of schools argued that the environments in which SPS could be improved effectively were the ones where teachers and students were active together. It can be inferred from the answers of SHS chemistry teachers that 50% of them employed SPS attainment activities through computer simulations or questions in teacher-centered classes unwittingly. More than 50% of AHS chemistry teachers indicated that they were trying to teach through ready-made computer environment programmes during which teachers and students were active together. Regardless of the type of school, more than 50% of the biology teachers stated that they frequently carried out activities to improve SPS in classrooms or laboratories through computer programmes during which teachers and students were active together. Most of the teachers believed that SPS could be attained actively through experimentation method in science classes. It can be understood from these statements that teachers cared about concept learning and they carried out experiments for this goal. Teachers' opinions about the impact of SPS on concept learning and the fact that all of them said a national-examination-focused teaching system for the reason of the problems faced during the attainment of these skills support this consequence.

All of the teachers expressed that lack of time due to intense curricula and national-examination-focused education system were the problems confronted during the attainment of SPS. More than 50% of the teachers in the study also considered insufficiency of students in basic process skills, lack of laboratories and materials, and pedagogical insufficiency of teachers in SPS as the barriers before the improvement of these skills in students. Most of them expressed that they were suffering from the inadequacy of sample activities in coursebooks and in-class activities. SHS teachers did not have the problem of crowded classrooms.

When the frequency of teachers' applications to improve SPS are viewed, it can be concluded that they rarely used experimentation methods whereas they frequently utilized in-class explanations and ready-made computer programmes, because it has been inferred that teachers carried out practices such as experimentation, measurement, designing experiment, data transfer in graphs or tables in laboratories once or twice a month or term. Teachers expressed that they often practised graph drawing and interpretation and hypothesizing skills. All of them stated that they had their students interpret graphs through questions rather than draw them. AL physics teachers remarked that they employed visual-spatial thinking skill practices once or twice a month or term.

When teachers' comments about their identification levels of SPS in the given scenarios are analyzed, it can be viewed that more than 50% identified observation, prediction, data recording, comparison, experimentation, and conclusion skills in Scenario 1 and observation, experimentation, interpretation, conclusion, and comparing skills in Scenario 2 what SPS were identified in which sentences were shown in some of the answers and only identified SPS were listed in some of them. When the teachers' answers are analyzed, a parallelism can be observed between school and branch types in the identification of teachers' SPS. It can be inferred that teachers were generally good at specifying the statements in the scenarios in terms of SPS. However, they used inference skills as prediction skills or specifying and changing variables skills; few teachers were successful in the skills of specifying and changing variables and keeping them constant; therefore, few teachers were able to identify measurement skills. Before the study, SHS teachers had been expected to be more successful than AHS teachers in practising and identifying SPS as they guide students in end-of-school projects and as SHS teach more science classes compared with other types of schools within the scope of their vision and mission; but this did not happen. Regarding teacher opinions and their identification levels, it can be understood that they didn't particularly practise toward improving SPS, that they employed these skills through animations in computer environment and question solving exercises, that the experiments which were hardly carried out aimed at concept teaching rather than scientific skill attainment or these experiments were only demonstration experiments. Türkmen and Kandemir (2011) defined through the study conducted with science teachers that teachers thought SPS could be improved through projects and assignments or associating them with everyday life experiences. The researcher stated that teachers generally thought that these skills could be improved through methods suitable for a constructivist approach (collaborative learning, group studies, etc.). The Jeanpierre et al. (2004) study about this issue showed that deep science content and development of science process skills with numerous opportunities for teachers to practice using integrated science processes and research skills should be aimed in professional development programmes.

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