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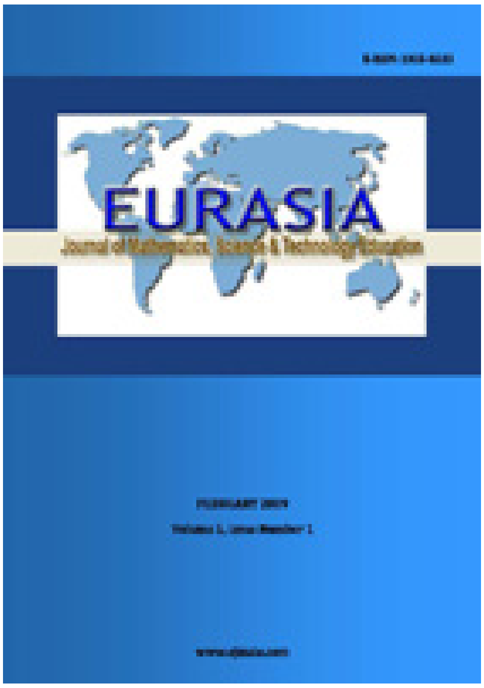

Students' Science Process Skills within a Cognitive Domain Framework

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Received 13 November 2011; accepted 27 March 2012
Published on 28 October 2012

APA style referencing for this article: Ozgelen, S. (2012) Students' Science Process Skills within a Cognitive Domain Framework. *Eurasia Journal of Mathematics, Science & Technology Education*, *8*(4), 283-292.

Linking to this article: DOI: 10.12973/eurasia.2012.846a

URL: http://dx.doi.org/10.12973/eurasia.2012.846a

ISSN: 1305-8223 (electronic) 1305-8215 (paper)

The article starts with the next page.

Eurasia Journal of Mathematics, Science & Technology Education, 2012, **8**(4), 283-292

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The purpose of this study was to investigate Turkish primary students' scientific process skills under the theoretical framework of cognitive domain. The sample set consisted of 306 sixth and seventh grade students from public, private, and bussed schools. The Turkish Integrated Process Skill Test was used to measure scientific process skills, and the findings showed generally low scores. However, results indicated significant differences between sixth and seventh grade students at private and public schools. In addition, significant differences emerged among sixth grade students at each school type. Private school students had higher scores compared to public and bussed school students. Similarly, a significant difference was determined between sixth grade students at public and bussed schools. At the seventh grade level, private school students scored significantly higher than students at public and bussed schools. These differences are explained and discussed under the framework of cognitive domain and possible reasons for science achievement are identified.

Keywords: science process skills, cognitive domain, primary students

INTRODUCTION

What is science? This question has many answers, but no single accepted definition. One explanation involves the understanding of existing knowledge and the continual process of generating new knowledge (Johnson & Lawson, 1998). More specifically, science consists of two components, (a) scientific knowledge and (b) the acquisition of scientific knowledge. Facts, laws, hypotheses, and theories constitute such scientific knowledge. The acquisition of scientific knowledge also has two dimensions: affective domain and cognitive domain. In this study, the focus is science process skills and their relationship to the cognitive domain.

Science process skills (SPS) are the thinking skills that scientists use to construct knowledge in order to solve problems and formulate results. The scientific method, scientific thinking, and critical thinking are also terms that have been used to describe these skills, but last two decades, the phrase "science process skills" has become more common (Bybee & DeBoer, 1993). When scientists conduct investigations, they use SPS to discover scientific knowledge (Abruscato, 1995), which is explained as describing, predicting, explaining, and adapting to phenomena of the natural world (Carin, Bass, & Contant, 2005). Some researchers (Brotherton & Preece, 1995) argue that SPS can be explained by a two-level hierarchical model of basic and integrated skills.

For this study, SPS has been separated into Basic Science Process Skills and Integrated Science Process Skills. Basic SPS consists of observing, using space/time relationships, inferring, measuring, communicating, classifying, and predicting. Integrated SPS includes controlling variables, defining operationally, formulating hypotheses, interpreting data, experimenting, formulating models, and presenting information.

The first piece of basic SPS is gathering data about objects and events using all appropriate senses or with instruments extend the senses, such as magnifying glasses, telescopes, microphones, speakers, and medical

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ISSN: 1305-8223

State of the literature

- Science process skills (SPS) are the thinking skills that scientists use to construct knowledge in order to solve problems and formulate results.
- One of the goals of science education is to teach the effective thinking defined by SPS. Science education should include an emphasis on hypothesizing, manipulating the natural world, and data-based reasoning.
- Recent reforms hold great promise towards teaching SPS to all students. Educators recognize the value of these skills with respect to personal, intellectual, and social development. Some educators emphasize the importance of teaching SPS in science education, but, more abstractly.

Contribution of this paper to the literature

- The conceptual framework of SPS and related cognitive domains are classified as information processing skills, reasoning skills, inquiry skills, creative thinking skills, and problem solving skills.
- This study that demonstrates the relationships among the main conceptual framework of cognitive domain and SPS.
- There is a close link between cognitive development and SPS. International studies reveal that students' science achievements are directly related to parents' socio-cultural status and education levels, the number of books in the home, and having computer and internet access. Moreover, there is closely relationship between students' achievements and their science process skills.

implements. Such observation is the most basic process of science (Abruscato, 1995; Carin, et al., 2005). Measuring, a quantitative representation of observation, indicates assigning values to variables using instruments and defined units. Skills in measuring require the knowledge to use equipment appropriately and to perform necessary calculations (Abruscato, 1995; Carin, et al., 2005). Classifying, another piece of basic SPS, is a process used by scientists to categorize objects based on similarities, differences, and interrelationships among objects (Abruscato, 1995; Carin, et al., 2005). Next, inferring refers to developing possible conclusions about observations based on prior knowledge. Predicting, yet another component, means making a specific statement about what will happen in the future, an essential part of science. Accurate predictions require careful observations and correct measurements (Abruscato, 1995; Carin, et al., 2005). Communicating is essential to human endeavor and fundamental to scientific work, and relevant ideas can be shared through words, diagrams, maps, and graphs (Abruscato, 1995).

Integrated SPS requires a more advanced knowledge base. For instance, identifying and controlling variables is an essential skill for successfully managing a scientific investigation (Abruscato, 1995; Carin, et al., 2005). Defining these variables operationally requires boundaries to be considered. Depending on the discipline, an operational definition will vary; for example, in physical science, it is based on what is done and observed. On the other hand, in biological sciences, an operational definition is often descriptive (Abruscato, 1995). Formulating hypotheses, or making a statement about a possible relationship in the natural world, is another fundamentals skill based on accurate observations or inferences. Interpreting data involves other SPS, such as making predictions, inferences, and hypotheses from collected data. Students should have previous experience observing, classifying, and measuring before interpreting data. Experimenting involves all basic and integrated processes, beginning with observations that lead to identifying variables to be controlled, developing operational definitions, constructing and conducting a test, collecting and interpreting data, and, when necessary, modifying hypotheses (Abruscato, 1995).

Historical Background of SPS

One of the goals of science education is to teach the effective thinking defined by SPS. Science education should include an emphasis on hypothesizing, manipulating the natural world, and data-based reasoning. The goals of science education have shifted over time, subsequent to science curricula and instructional development. According to Bybee and DeBoer (1993), two main questions should be considered in regards to science education. First, what science should be learned? The three main goals are to acquire scientific knowledge, to learn the process of methodologies of the sciences, and to understand the applications of science, the relationships between science and science-technology-society. Bybee and DeBoer (1993) explain these relationships:

> *"Method is a manner of acting, a predisposition to behave, perform, and think in certain ways toward an object or objects of study. Of particular importance here are scientific methods as they have been variously described in the history of science education. One example of method as stated goal of science teaching is the process of science. Emphases on inquiry, discovery, and problem solving are further examples of the method goal of science education(p. 358)"*

Bybee and DeBoer's (1993) second question is, "Why should students learn science?" Answers can include personal development, social efficacy, the development of science itself, and national security. Personal development refers to intellectual and moral growth, personal satisfaction, career awareness, and obtaining necessary science process skills. According to what and why of science teaching goals are; personal and social development, knowledge of scientific facts and principles, and scientific methods and skills and their application.

Scientific literacy is a prominent goal of science education, and a scientifically literate person "uses scientific concepts, process skills, and values in making everyday decisions as he interacts with other people and with his environment...[and] understands the interrelationships between science, technology and other facets of society, including social and economic development" (National Science Teacher Association [NSTA], 1971). Evident in the NSTA's statement are themes of social relevance, student interest, relationships between science and the curriculum, the interdependence of science and technology, and human aspects of scientific enterprise. What is abandoned, however, is the idea that the structure and process of science should be studied for their own sake. The overarching aims of education are to teach aspects of science that help students understand the world around them and to provide them with tools for acquiring new scientific knowledge (Bybee & DeBoer, 1993).

Contemporary curriculum should emphasize scientific habits, such as cooperation when answering questions and solving problems. Program content should be relatable for students and provide a context for new knowledge, skills, and attitudes. The focus of curriculum and instruction should be in-depth study rather than a breadth of topics. SPS should be instilled in all students, especially during the elementary education (NSTA, 1982), which is not just for students anticipating careers in science and engineering. Achieving scientific literacy requires more than simply understanding major concepts, but also acquisition of SPS.

Recent reforms hold great promise towards teaching SPS to all students. Most educators recognize the value of these skills with respect to personal, intellectual, and social development. Some educators emphasize the importance of teaching SPS in science education, but, more abstractly, SPS encompasses the mental and physical skills for collecting and organizing information and then using it to make predictions, explain phenomena, and solve problems. Students can gain practice and become experts at using these processes through emphasis in science education (Carin, et al., 2005).

According to National Research Council (NRC) standards, SPS is integrated into the broader abilities of scientific inquiry; therefore, the standards include the "process of science" and require that students combine processes and scientific knowledge to develop their understanding of science. One of the goals of these standards, students' use of "appropriate scientific processes and principles in making personal decisions," is an important cornerstone in science teaching (NRC, 1996, p. 13). The relationship between inquiry and SPS is further explained by the NRC:

> *"Students at all grade levels and in every domain of science should have the opportunity to use scientific inquiry and develop the ability to think and act in ways associated with inquiry, including asking questions, planning and conducting investigations, using appropriate tools and techniques to gather data, thinking critically and logically about relationship between evidence and explanations, and communicating scientific arguments" (1996, p. 105).*

Recently, several important revisions have been made in the global elementary science curriculum involving an emphasis on skills, attitude, and value dimensions (Ministry of National Education [MoNE], 2004). MoNE began implementing these revisions in Turkish elementary science curriculum in 2004. The vision of the new program is that all students will be science literate regardless of individual differences (MoNE, 2004). Science literacy includes seven dimensions: (a) the nature of science and technology; (b) key science concepts; (c) SPS; (d) the relationships between science, technology, society, and environment; (e) scientific and technique psychomotor skills; (f) values constructing the essence of science; and (g) attitude and values toward science (MoNE, 2004). According to these dimensions, a key aim of the new Turkish elementary science curriculum is for students to use SPS to make their own decisions.

Conceptual Framework

The conceptual framework of SPS and related cognitive domains are classified as information processing skills, reasoning skills, inquiry skills, creative thinking skills, and problem solving skills.

Cognitive Domain and SPS

Piaget (1966) established one of the most important theories to explain intellectual development, and it can be used to clarify the relationship between cognitive domain and SPS. Piaget investigated how individuals perceive their environments and the world based on observations and interviews with children about their reactions to events from birth to adolescence. According to his findings and resultant theory, the cognitive structures of learners change dependent upon individual-environmental interaction.

According to Piaget's theory, in order to adapt to an environment, learners face two stages, assimilation and accommodation. First; "Assimilation is a cognitive process by which a person integrates new perceptual, motor, or conceptual matter into existing schemata or patterns of behavior" (Wadsworth, 1996, p. 17). Thus, if a person has similar experiences, she or he can assimilate easily. With respect to accommodation, Wadsworth explains, "When confronted with a new stimulus a child tries to assimilate it into existing schemata. Sometimes this is not possible, so an individual can create a new schema in which to place the stimulus or one can modify an existing schema so that the stimulus fits into it" (1996, p. 17). While constructing new schema, one's environment affects his or her cognitive structure.

Piaget's identifies four consecutive stages of intellectual development, generally categorized by age ranges (Piaget, 1966). The last stage, the formal operational stage, begins around 11 or 12 years of age and allows for successful learning of abstract science content matter. In this stage, students can reason without reference to concrete objects, events, or actions, and theoretical, propositional, hypothetical, and combinatorial reasoning patterns are characteristic. Students are able to establish their own plans for long and detailed projects if given aims and goals. Formal operational stage characteristics require more complex and integrated SPS. Formal Reasoning is a set of operations (or schemata) that characterizes the quality of thought at the formal-operational stage of development. The schemata includes the ability to isolate and control variables, to recognize proportional relationships, to determine all possible combinations of a set of objects, to calculate the probability of an event, and to identify correlational relationships (Monteyne, 2004). Many studies about Piagetian theory have revealed positive correlations between students' formal reasoning abilities and their achievements in science, mathematics, and social sciences (Lawson, 1985; Shayer & Adey, 1993). The term formal reasoning abilities are typically used by researchers to define more complex skills and integrated SPS.

Thinking Skills and SPS

Thinking is a general and extensive term used to describe intellectual functions. Because thinking is a mental process, it cannot be observed directly, but some actions reflect thinking and are known as thinking skills. No common taxonomy of thinking skills has been set forth in the literature, but they have been classified by McGregor (2007), as information processing skills, reasoning skills, enquiry, creativity, and evaluation (see Table 1).

Functions in Table 1 such as classifying, inferring, predicting outcomes, and hypothesizing refer directly or indirectly to SPS. Educators have developed programs to facilitate students' thinking skills in areas like science, mathematics, and technology. One important program is the Cognitive Acceleration through Science Education (CASE), developed by Shayer and Adey (1993) to promote complex levels of thinking. They employed a

Table 1. Categorization of Thinking Skills (McGregor, 2007, p. 33)

Thinking Skills Descriptor	Related Cognitive Functions
Information processing skills	• Finding relevant information • *Sorting/classifying/sequencing* information • *Comparing/constructing* information • *Identifying and analyzing* relationships
Reasoning skills	• Giving reasons for opinions/actions • *Inferring* • *Making deductions* • Making informed judgments • Using precise language to reason
Enquiry	• Asking questions • Defining questions for enquiry • *Planning research* • *Predicting outcomes* • *Anticipating consequences* • *Drawing conclusions*
Creativity	• *Generating ideas* • Developing ideas • *Hypothesizing* • Applying imagination • *Seeking innovative alternatives*
Evaluation	• Developing evaluation criteria • Applying evaluation criteria • *Judging the value of information and ideas*

two-year intervention program based on Piagetian reasoning patterns. The study revealed that cognitive development achieved by students observed in a short-term period effects of cognitive development on science learning observed in a longer-term period. At the end of the program, students' processing abilities had progressed beyond the expected average. Adey and Shayer (1990) showed that acceleration of formal reasoning ability was possible among middle and high school students through long-term studies.

Creative Thinking Skills and SPS

Creative thinking is defined as "the generation or suggestion of a unique or alternative perspective, the production of an innovative design or a new approach to a problem or artistic challenge" (McGregor, 2007, p. 172). Within each existing thinking skills program, there are opportunities for the development of creative thinking. For instance, the Cognitive Acceleration (CA) program offers occasions for creative thinking when students are asked to predict events. Students not only think about "what," but also "why" (McGregor, 2007). In the CASE approach (Shayer & Adey, 1993), the development of hypotheses is also highly emphasized. Generating new, original ideas is an important part of creativity; often referred to as hypothesizing, it is one of the most important pieces of integrated SPS, as well.

Problem Solving Skills and SPS

Problem solving can be defined as flexible thinking to develop the skills needed to face challenges in everyday life (McGregor, 2007). Ten steps for problem solving and their relationship to cognitive and thinking skills (Table 2). As shown in Table 2, the first four steps of the problem solving process are related with basic SPS: observing, classifying, measuring, predicting, inferring, predicting, and communicating; skills such as experimenting, analyzing, synthesizing, decision making, and evaluating, meanwhile, are related to integrated SPS.

Figure 1 shows a model developed for this study that demonstrates the relationships among the main conceptual framework of cognitive domain and SPS. The model was formed by taking into consideration of the Table1, the Table 2, and the SPST questions. The conceptual framework consist of information processing skills, reasoning skills, inquiry skills, creative thinking skills, evaluation skills, and problem solving skills. Because cognitive domain extends beyond the conceptual framework, it is at the bottom and the top of the model. This model shows that SPS is directly related to the framework of cognitive domain. Arrows indicate the direction of relationships, and the thickness of an arrow emphasizes the frequency of interaction.

METHODOLOGY

In this study, quantitative data were gathered from Turkish primary students. The data were analyzed according to descriptive and inferential statistics techniques (Gravetter & Wallnau, 2007). Results were explored under the cognitive domain framework.

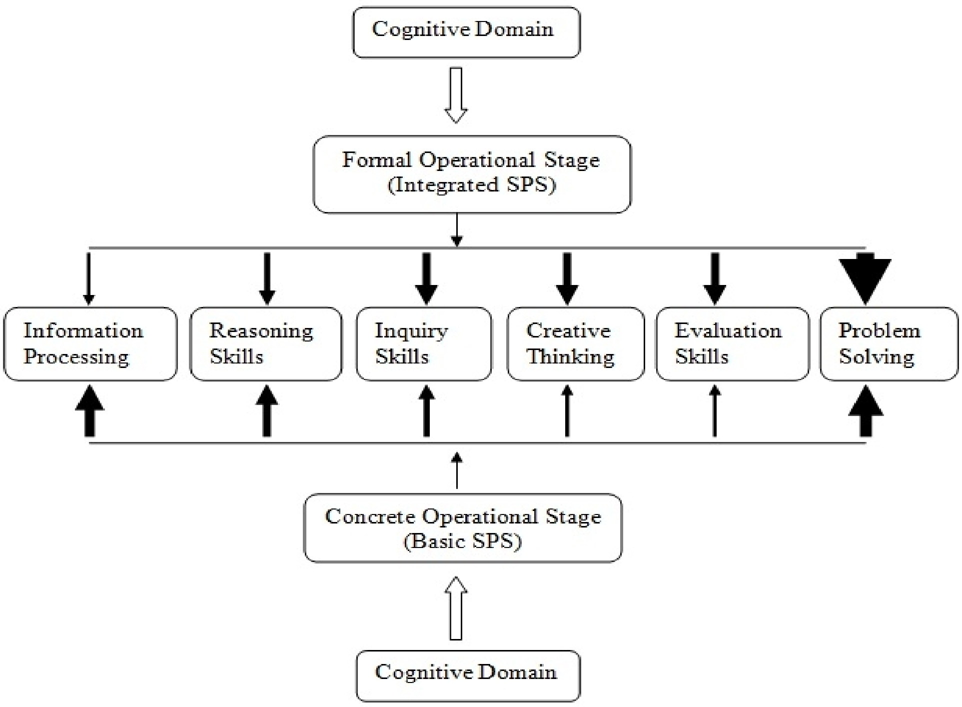

Figure 1. Conceptual framework of cognitive domain and SPS

Table 2. Problem Solving Processes and Thinking Skills (McGregor, 2007, p. 241).

Step in Problem Solving Process and Key Question	Related Thinking skills
1. Clarification of the task or problem What are we trying to do?	• *Defining* • *Clarifying* • *Representing information* • Simple analysis
2. Identification of important factors What matters?	• Selecting information • *Comparing and contrasting* • Evaluating • *Connecting cause and effect* • *Predicting* • *Hypothesizing*
3. Considering possible solutions How could we solve it?	• Predicting/Extrapolating • *Recognizing how information could be collected* • *Sequencing and ordering actions* • *Generating new ideas*
4. Identifying different strategies What are the different ways we could solve this problem?	• *Recognizing tasks and subtasks* • *Developing alternative methods* • Comparing and contrasting • Sequencing actions
5. Comparing and contrasting Which method would be best? Why?	• *Comparative thinking* • Evaluating • Setting up goals and sub goals
6. Applying and trialing the selected method Do you have everything you need?	• Evaluating • *Reviewing* • *Predicting* • Extrapolating
7. Part way through the process Is it working?	• *Analyzing* • *Synthesizing* • Evaluating • Making decisions
8. Describing the solution What does the solution look like?	• Reviewing • *Evaluating* • *Elaborating* • *Decision making*
9. Was the problem solved? How far did our method solve the problem?	• Evaluating • *Reviewing* • *Reflecting* • *Reasoning* • Sequencing • Synthesizing
10. Transferring thinking processes and outcomes. Where else would you use this kind of problem solving strategy?	• *Reflecting* • *Synthesizing* • *Analyzing* • *Comparing* • *Reasoning* • *Extrapolating*

Research Questions

This study aimed to investigate Turkish primary students' scientific process skill under a theoretical framework of cognitive domain. Two research questions were addressed:

- *Are there any differences in students' SPS for each school type from a combined sixth/seventh grade perspective?*
- *Are there any differences in students' SPS among school types for each grade level?*

Sample

The target population for the sample was sixth and seventh grade students from private, public, and bussed primary schools in Ankara, the capital of Turkey. In Turkey, formal education includes pre-primary, primary, secondary, and higher education. Primary education is compulsory for all children ages 6 to 13 and provided for free at State schools. It consists of eight years of continuous schooling. The participants were from three different primary education institutions: public, private, and bussed, for students who are transported to other locations. The approximate distribution of primary students is as follows: 10 million in public schools, 1 million in bussed schools, and 300,000 in private schools (MoNE, 2011). The sample was chosen from the accessible population via convenience sampling among five classes in private schools, four classes in public schools and two classes in a bussed school. A total of eleven classes (306 students) formed the sample (Table 3).

Instrument

In this study, the Integrated Process Skill Test (SPST) (Burns, Okey, & Wise, 1985) was used to measure primary students' scientific process skills. The Turkish version of the test was adapted by Geban, Askar, and Ozkan (1992). The initial test included 36 multiple choice items, but after reliability studies were conducted (Aydogdu, 2006; Geban, Askar, & Ozkan, 1992; Serin, 2009), the final form consisted of 25 multiple choice items with a reliability coefficient of 0.81. During analysis, each correct answer earned one point, while each wrong or unanswered item earned zero points. The maximum possible score is 25, and the minimum, zero. Higher scores indicate more sophisticated science process skills.

Table 3. Number of Students by Grade, Class, and School Type

School Type	Grade	Classes	Class Size
Private	6th	3	20-20-21
Private	7th	2	19-18
Public	6th	2	31-34
Public	7th	2	27-31
Bussed	6th	1	46
Bussed	7th	1	39
Total		11	306

FINDINGS

The analysis of the quantitative data took two steps. First, a data-cleaning phase was conducted to examine missing cases and outliers using descriptive statistics (mean, minimum, maximum, and SD) for the SPST.

Descriptive Statistics

As this study was not concerned with gender differences, related data were not analyzed. Gender distribution was approximately equal. Turkish primary students' scores of the SPST are given in Table 4.

According to Table 4, Turkish primary students' SPST mean scores were very low, the highest score being 15.43 out of 25. The lowest mean, 8.78, was recorded for bussed sixth grade students, while the highest mean, 15.43, was reported for private seventh grade students. In addition, sixth grade private school students' mean was calculated to be 12.04 as the highest score among sixth graders. Moreover, total means were found according to school types for private school as 13.32, for public school as 11.24, and for bussed school as 9.23. The total mean score for all of the students was 11.23 points.

Inferential Statistics

In order to answer the research question about differences in SPST scores among sixth and seventh grade students, paired-sample t-tests were conducted for each school type. The results are presented in Table 5.

Table 5 shows a statistically significant difference between sixth and seventh grade students in the private school (p=.001). The eta squared statistic (.13) indicated a large effect size (Cohen, 1988) high enough to warrant practical significance. In addition, Table 5 shows a statistically significant difference between sixth and seventh grade students in the public school (p=.024). The eta squared statistic (.04) indicated a moderate effect size (Cohen, 1988). There was not a statistically significant difference (p=.490) between sixth and seventh grade students in the bussed school.

Table 4. Descriptive Statistics for the SPST

SPST	N	Mean	SD	Skewness	Kurtosis	Min.	Max.
Private 6th	61	12.04	4.12	0.37	-0.54	5	22
Private 7th	37	15.43	3.88	-0.68	0.16	6	23
Public 6t	65	10.33	4.43	0.78	-0.49	5	21
Public 7th	58	12.35	4.71	0.15	-0.98	5	22
Bussed 6th	46	8.78	3.65	0.32	0.31	2	18
Bussed 7th	39	9.76	4.18	0.33	-0.51	3	20
Pri. 6th & 7th	98	13.32	4.33	-0.01	-0.90	5	23
Pub. 6th & 7th	123	11.24	4.65	0.46	-0.99	5	22
Bus. 6th & 7th	85	9.23	3.91	0.37	-0.14	2	20

For the second research question, paired-sample t-tests were first conducted to compare sixth graders according to their school types. The results are given in Table 6.

Results indicated a statistically significant difference between all points of comparison. For private and public sixth grade students (p=.035), the eta squared statistic (.03) indicated a point between a small and moderate effect (Cohen, 1988), enough to warrant practical significance. There was also a statistically significant difference between private and bussed sixth grade students (p=.000). The eta squared statistic (.16) indicated a large effect size (Cohen, 1988). Finally, there was a statistically significant difference between public sixth and bussed sixth grade students (p=.028). The eta squared statistic (.04) indicated between small and moderate effect size (Cohen, 1988).

Seventh grade students were also compared according to their school types via paired-sample t-tests. The results are presented in Table 7.

Table 7 shows a statistically significant difference between private and public seventh grade students (p=.005). The eta squared statistic (.09) indicated a point between moderate and large effect (Cohen, 1988). There was also a statistically significant difference between private and bussed seventh grade students (p=.000). The eta squared statistic (.42) indicated a large effect size (Cohen, 1988). However, no statistically significant difference emerged between public and bussed seventh grade students (p=.060).

DISCUSSION AND IMPLICATION

Developing SPS is crucial to improve primary students' science achievements (Lawson, 1985; Shayer & Adey, 1993). The SPST results showed low scores for Turkish primary students in sixth and seventh grades at all school types. Although the elementary science curriculum of the post-reform period emphasizes the importance of SPS, students did not earn high scores from the SPST. This result is consistent with international studies, such as Trends in International Mathematics and Science Study (TIMSS). In TIMSS 1999, Turkish students' scientific inquiry (related to SPS) achievements was found to be 445, lower than international average of 488 (ISC, 2000). After the new curriculum for elementary schools was implemented in Turkey, TIMSS 2007 reported relative improvement to a score of 462, but Turkish students still scored below the international average of 500 (ISC, 2007). This gap can be explained by the difference between intended and implemented science curriculum in schools since textbooks, curriculum, and contents of national examinations were found compatible in Turkey after the reform movement of 2004 (Incikabi, 2011). Moreover, this result echoes past studies, which found that student failure in science can be attributed to inefficient use of SPS (Kwon & Lawson, 2000; Shayer & Adey, 1993; Valanides, 1996).

Results also indicated significant differences between sixth (age of twelve) and seventh (age of thirteen) grade students at private and public schools. This difference can be explained by primary students' developmental

Table 5. Paired-Sample t-test Results According to Class

School Classes	T	df	Effect Size
Pri. 6th & 7th	-3.70*	36	0.13
Pub. 6th & 7th	-2.32**	57	0.04
Bus. 6th & 7th	-0.69	38	----

*$p < .005$, **$p < .05$

Table 6. Paired-Sample t-test Results According to School Type

School Type	T	df	Effect Size
Pri. 6th & Pub. 6th	2.15**	60	0.03
Pri. 6th & Bus. 6th	4.52*	45	0.16
Pub. 6th & Bus. 6th	2.27**	45	0.04

*$p < .005$, **$p < .05$

Table 7. Paired-Sample t-test Results According to School Type

School Types	T	df	Effect Size
Pri. 7th & Pub. 7th	3.02*	36	0.09
Pri. 7th & Bus. 7th	7.28*	36	0.42
Pub. 7th & Bus. 7th	1.94	38	----

*$p < .005$

levels according to Piagetian theory. Piaget claimed a positive correlation between children's mental capacity for processing information and their ages. Piaget stressed that formal thought appears at about eleven; therefore, most high school students should exhibit relevant characteristics. However, similar to the current study, research indicates that many high school students do not have the mental capacity for this type of thinking (Kwon & Lawson, 2000; Lawson & McElrath, 1991; Tobin & Capie, 1981).

There is a close link between cognitive development and SPS. Brotherton and Preece (1995) state that some reasoning patterns of Piaget's formal stage can equally be considered SPS. The same study revealed a substantial overlap between these two constructs: Formal stage and developmental SPS. Indeed, students at the concrete level can successfully implement basic SPS; students at the formal level can implement integrated SPS (Brotherton & Preece 1995). In the formal operational stage, students use integrated SPS, including identification and control of variables, proportional thinking, probabilistic thinking, and correlational thinking. These skills can predict students' achievements in science and mathematics (Bitner, 1991; Howe & Durr, 1982). The results showed no significant difference between sixth and seventh classes at the bussed school. Low scores for sixth (8.78) and seventh (9.76) grades can be attributed to insufficient cognitive levels. Griffiths and Thompson (1993) further indicate a high rate of misconceptions about SPS and a lack of development of formal reasoning patterns among secondary school students.

Findings indicated significant differences among sixth grade students at each school type, with private school students earning the highest scores. This difference may be related to parents' education levels (Muller, 1995; Samuelsson & Granström, 2007). Similarly, a significant difference emerged between sixth grade students at public and bussed schools. For the seventh grade level, private school students' scored significantly different higher. These results are consistent with national selection and placement examination (OKS) for high schools; according to science scores for OKS, private schools are more successful than public and bussed schools (MoNE, 2011). There are some factors to explain students' failure or their success for science and mathematics. Past studies pointed out some factors for instance, attitude, studying strategies, outdoor activities, and family effect etc. (Keith, 1982; Samuelsson & Granström, 2007).

International studies reveal that students' science achievements are directly related to parents' socio-cultural status and education levels, the number of books in the home, and having computer and internet access (ISC, 2007). Moreover, there is closely relationship between students' achievements and their science process skills. Past studies showed that science process skills are the other important factor affecting students' achievements (Baser & Durmus, 2010).

Science process skills are related to cognitive development, as shown in Figure 1. According to this figure, developing SPS supports students' thinking, reasoning, inquiry, evaluation, and problem solving skills, as well as their creativity. Therefore, future research needs to investigate these relationships more deeply via experimental studies.

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