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The Effects of an Instructional Intervention on 7th Grade Students' Science Process Skills and Science Achievement

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Abstract

The aim of this study is to investigate the effects of the instructional intervention on science process skills (SPSs) and science achievement of the 7th grade elementary students in Turkey. Non-equivalent control group quasi-experimental design was employed for research design. While an instructional intervention was performed in order to integrate the learning of science process for the experimental group, the control group received a regular teaching approach over the existing curriculum. The students were administered the Test of Scientific Process Assessment (TSPA) and achievement test as pre- and post-test. Although the difference between the experimental and control group related to the post-test scores of both the test of TSPA and the achievement test was not significant, it can be possible suggest that the experimental group improved their SPSs and achievements more than the control group via the instructional intervention. The results also indicated that there is a significant correlation between the students' SPSs and achievements in science.

Introduction

Improving both procedural and conceptual understanding and knowledge of science is an important component within the goals of the science education. To this end, common approach in the school-science is to create opportunities via practical works for students to engage in many aspects of science processes.

Reform efforts have been expanded worldwide to increase the quality of education, although these reform efforts are differ from nation to nation. For example, the educational reform movements in the United States, UK, and Australia emphasized that an understanding of the processes and the nature of science, accompanied the ability to do science inquiry, is a requirement for effective science education (American Association for the Advancement of Science [AAAS], 1990; Department for Education Science [DfES], 2004; Hackling, 2005; National Research Council [NRC], 1996). The wave of science education reform has affected Turkey like many countries as well. In Turkey, the Ministry of National Education (MoNE) has developed science and technology curriculum as part of a larger scale educational reform because Turkish students' performance in the national exams (high school and university entrance exams) and international student assessment studies (such as TIMSS and PISA) are low. The vision of the new science and technology curriculum for science education in Turkey is to provide scientific literacy to individuals whatever their individual differences are (MoNE, 2005). We see that the vision is parallel to that of The *National Science Education Standards* (NSES) in USA (NRC, 1996). *Inquiry is a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results* (NRC, 1996, p.23). Based on this

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description it can be suggested that scientific inquiry requires using of science process skills. Although the curriculum in Turkey does not sufficiently support inquiry-based approach, the science process skills including *observing, comparing-classifying, measuring, defining operationally, predicting, identifying variables, designing experiment, identifying and using experimental equipments and tools, collecting and recording data, modelling, inferring and drawing conclusion, hypothesizing, set up experiment, manipulating and controlling variables* are described as the skills which should be developed within the new curriculum at each grade level (4-8) for elementary education (MoNE, 2005). The new curriculum for middle school (grades 6, 7, 8) has been implemented gradually in Turkey since the 2005-2006 academic year.

The Education Reform Initiative (ERI) -in Turkish ERG- also evaluates Turkey's education system from different perspectives and presents education monitoring reports since 2008. In the light of results, students have not generally acquired science process skills although the SPSs are come into prominence in the new curriculum (Berberoğlu, Arıkan, Demirtaşlı, İş Güzel, & Özgen Tuncer, 2009). According to the education monitoring report 2010, the primary issue the Turkish education system faces today is that *learning* is not taking place at the desired level. Although a student-centred education system is not widely used in Turkey, the effectiveness of student-centred activities in improving thinking processes is directly related to the quality of these activities. However, the results of the report indicate that these student-centred activities do not subscribe to the desired quality criteria. (ERG, 2011, pp.6-17). Although the *standards* emphasize inquiry, this should not be interpreted as recommending a single approach to science teaching.

Teachers should use different strategies to develop the knowledge, understandings, and abilities described in the content standards (NRC, 1996, p.23). Practical works play a key role in developing both procedural and conceptual understanding and knowledge of science. All forms of practical work should be integrated carefully into an instructional sequence so that meaningful links can be established between the practical and theoretical aspects of science (Hackling, 2005, p.5). Considering the problems mentioned above, an instructional intervention can be seen as a tool to adapt the instructional goals to the goals of new curriculum during transitional period in the Turkish school system. In this sense, an instructional intervention was performed in order to integrate the learning of science processes into the flow of the science and technology course. The practical activities were redesigned by putting purposively an emphasis on certain aspects of science processes during the study.

Therefore, the aim of this study is to investigate the effect of the instructional intervention on the 7th grade elementary students' SPSs and science achievements. To this end, some answers to the following research questions are sought:

- Is there significant difference between experimental and control groups' post-test scores of the TSPA test?
- Is there significant difference between experimental and control groups' post-test scores of the achievement test?
- Is there any correlation between the scores of the TSPS and achievement test of the experimental group?

Method

Research Design

In this study, non-equivalent control group quasi-experimental design (Fraenkel & Wallen, 2000) was employed for research design.

Participants

This study was conducted with forty-three (n=23 in the experimental group, n=20 in the control group) 7^{th} grade students (21 female and 22 male) in Turkey. The method of convenient sampling was used.

Instruments

The Test of Scientific Process Assessment (TSPA) developed originally by Smith and Welliver (1995) and adapted into Turkish by Başdağ (2006) was administered to collect data. The instrument consists of 40 multiple-choice questions, and includes 13 SPS in total that are the skills of observing, classifying, drawing conclusion, predicting, measuring, recording/displaying data, space/time relations, defining operationally, formulating hypotheses, designing investigations and experimenting, controlling and manipulating variables, analysing data, and constructing a model. For this study, the reliability coefficient of the test was found to be 0.814. The test was administered to both groups as pre- and post-test in order to define the level of students' SPSs. The responses of the students were categorized as *correct=1*, and *incorrect* or *blank=0* by the researchers. Maximum score was 40 point for this test.

The test of achievement included 20 questions which were chosen from TIMSS 1999, 2003, and 2007 8^{th} grade (URL-1) by the researchers. Convenience toward the existing 7^{th} grade science and technology curriculum topics in spring semester was taken into consideration while the questions were chosen. The test consisted of 15 multiple-choice and 5 open-ended questions. The translation of questions from English to Turkish was checked by 3 English language experts and 3 science educators. The internal validity of the Turkish test was tested by 3 elementary science and technology teachers and 5 Turkish language teachers. The coefficient of cronbach-alfa was established as 0.741 for this study. Correct answers for multiple-choice questions were evaluated as 1 point, and incorrect answers were evaluated as 0 point. The explanations published of TIMSS questions and answers on the internet were based in order to evaluate of the open-ended questions. Correct explanations were evaluated as 2 point, partial corrects were evaluated as 1 point, and wrong answers were evaluated as 0 point (URL-1). The resources of questions are displayed in Table 1.

More specifically, the course for the experimental group included: (1) Designing multiple types of experimental activities, (2) Integrating scientific content and procedural knowledge in practical work, (3) Guiding and emphasizing certain aspects of science process, (4) Using worksheets and experiment reports for data collection. Both in-class and out-class experimental activities were included in the syllabus of this course. A series of worksheets with scaffolding that drew attention to the elements of scientific practice were designed in a systematic way to allow students to practice science, and these worksheets were given as instructional guidance to the experimental group. Students were allowed to work in their own groups, but also asked the experimental group students to work independently on written reports of the experiment. Feedback was given to the experimental group on worksheets and experiment reports for each activity practiced, and the students were encouraged to think about the connection between scientific content knowledge and procedural skills.

Table 1. *The Resources of Questions for the Test of Achievement*

No	The Resources of Questions	Item Number	Cognitive Domain
1	TIMSS 1999 8th-Grade	H03	Understanding simple information
2	TIMSS 1999 8th-Grade	J09	Theorizing, analyzing and solving problems
3	TIMSS 1999 8th-Grade	X02A- X02B	Theorizing, analyzing and solving Problems
4	TIMSS 1999 8th-Grade	B06	Understanding simple information
5	TIMSS 1999 8th-Grade	D01	Understanding complex information
6	TIMSS 1999 8th-Grade	F02	Understanding complex information
7	TIMSS 1999 8th-Grade	J03	Understanding complex information
8	TIMSS 1999 8th-Grade	F04	Understanding complex information
9	TIMSS 2003 8th-Grade	S022187	Conceptual understanding
10	TIMSS 2003 8th-Grade	S032574	Conceptual understanding
11	TIMSS 2003 8th-Grade	S012040	Conceptual understanding
12	TIMSS 2003 8th-Grade	S012025	Factual knowledge
13	TIMSS 2003 8th-Grade	S032202	Reasoning and analyzing
14	TIMSS 2003 8th-Grade	S012004	Conceptual understanding
15	TIMSS 2007 8th-Grade	S032516	Applying
16	TIMSS 2003 8th-Grade	S022058	Conceptual understanding
17	TIMSS 2007 8th-Grade	S042276	Applying
18	TIMSS 2007 8th-Grade	S042155	Applying
19	TIMSS 2007 8th-Grade	S022181	Knowing
20	TIMSS 2003 8th-Grade	S022202	Factual knowledge

The part of study regarding the unit of "Structure and Properties of Matter" was performed at three different phases. In the first phase, the students carried out practical work explicitly concentrated on the basic skills (e.g., observing, classifying, predicting, etc.) before the period emphasizing the open investigation. In the second phase of this part, they worked by shifting the focus from the basic to integrated process skills. In this phase, SPSs which were the subject to this phase were tried to be improved gradually by adapting from *Scientific Process Skills Relevant Alternative Assessment (AASPS)* method, which was used by Germann and Aram (1996). Instructional scaffolding was used to help students in making links between the science process skills and content knowledge of science. Then, a task in the same subject was given to the students, and they were asked to work on it independently as out of class work. In the third phase, activities were executed as open-ended experiment via scaffolding given in Appendix A.

The part of the study related to the unit of "Light" was held through experiments extending from structured and partial to open-ended to put more emphases on the SPSs (such as done by Aktamış in 2007).

In the part of the study on the unit of "Human and Environment", some activities were designed as an example of how projects could be designed to examine whether the students could use their SPSs. It was especially focused on the skills of scientific communication via preparing poster and PowerPoint presentation throughout this part.

The study lasted for approximately 18 weeks during one academic semester. The process of the study is given in Appendix B.

Data Analysis

Data obtained was analyzed by using the Statistical Package for the Social Sciences (SPSS) version 11.5 for Windows computer program. Independent and paired t-test were utilized in analysing data and the results were assessed at 0.05 level of significance. A Pearson Product Moment Correlation Coefficient (r) was also calculated between the post-test scores of TSPA and achievement test.

Results

Data collected was analyzed using statistical techniques, and results obtained are displayed by referring to the questions respectively.

Is There a Significant Difference Between The Experimental And Control Groups' The Post-Test Scores Of The Tspa Test?

First, the scores of experimental and control groups' pre-test TSPA were compared by employing t-test for independent groups. Results revealed that there was not any significant difference at 0.05 level between the groups for pre-tests. Then, independent sample t-test was conducted to compare the scores of experimental and control groups' post-test TSPA and results obtained are given in Table 2.

Table 2. *Comparison of Experimental and Control Groups' Scores on Post-Test TSPA*

Group	n	$X_{(mean)}$	SD	df	t	p
Experimental	23	30.087	6.089	41	1.922	0.062
Control	20	25.950	8.003			

p>0.05

As shown in Table 2, the independent sample t-test analysis reveals that there is no statistically significant differences between post scores of both groups' SPSs ($t_{(41)} = 1.922$; $p>0.05$). However, an increase in favour of the experimental group seems. Additionally, paired sample t-test was used to compare the scores of experimental and control groups' pre- and post-test TSPS. Results obtained are displayed in Table 3.

Table 3.*Findings for Paired Sample t-test of the Experimental and Control Groups' SPSs*

Group	Measurement	n	$X_{(mean)}$	SD	df	t	p
Experimental	Pre-test	23	27.522	7.096	22	-2.613	0.016*
	Post-test	23	30.087	6.090			
Control	Pre-test	20	25.450	7.145	19	-0.783	0.443
	Post-test	20	25.950	8.003			

*p<0.05

The data displayed in Table 3 reveals that there is a significant difference in favour of the post-test between pre- and post-test of TSPS in the experimental group's SPS levels ($t= -2.613$, $p<0.05$). Working through the course, they seemed to have moderately improved their using SPS levels. However, there is only a slight change and not a significant difference in the control group's SPS levels ($t= -0.783$, $p>0.05$). In the light of the results obtained from Table 2 and Table 3, it can be suggested that the instructional intervention by emphasizing SPSs, to some extent, had positive effect on improving students' SPSs.

Is There a Significant Difference Between The Experimental And Control Groups' The Post-Test Scores of The Achievement Test?

First, whether there was a difference between the experimental and control groups in terms of pre-achievement was examined by employing t-test for independent groups. The results obtained from preliminary analysis of pre-achievements revealed that there was not any significant difference at 0.05 level between the groups for pre-tests. Then, comparisons between experimental and control groups' post-achievements were made using independent sample t-test and results obtained are given in Table 4.

Table 4.*Comparison of the Experimental and Control Groups' Scores on Post-test of Achievement*

Group	n	$X_{(mean)}$	SD	df	t	p
Experimental	23	14.782	3.410	41	1.622	0.112
Control	20	13.100	3.370			

$p>0.05$

As presented in Table 4, although there is no statistically significant differences ($t_{(41)} = 1.622$; $p>0.05$) between two groups' achievement, an increase in favour of the experimental group's post-test levels is seen. Additionally, to compare the scores of experimental and control groups' pre- and post-test achievement, paired sample t-test was used. Table 5 shows the results on achievement.

Table 5.*Results for Paired Sample t-test of the Experimental and Control Groups' Achievement*

Group	Measurement	n	$X_{(mean)}$	SD	df	t	p
Experimental	Pre-test	23	11.130	3.545	22	-5.426	0.000*
	Post-test	23	14.782	3.410			
Control	Pre-test	20	11.650	3.990	19	-2.201	0.040*
	Post-test	20	13.100	3.3370			

*$p<0.05$

The results, as shown in Table 5, indicate that there is a significant difference at the $p=0.05$ level in favour of the post-test scores of achievement test for both experimental and control groups.

Further analysis was performed on the students' scores related to cognitive domains in the achievement test in order to examine whether or not there is a significant difference for each cognitive domain which is understanding simple information; theorizing, analyzing and solving problems; understanding complex information; conceptual understanding; factual knowledge; reasoning and analyzing; applying; and knowledge. The results obtained from paired sample t-test of cognitive domain are presented in Table 6.

Table 6.*Results of Paired Sample t-test for Achievement Measured Through Cognitive Domain*

Cognitive Domain	Group	Test	n	$X_{(mean)}$	SD	df	t	p
Understanding Simple Information	Experimental	Pre-test	23	1.695	0.470	22	-2.152	0.043*
		Post-test	23	1.869	0.344			
	Control	Pre-test	20	1.900	0.307	19	-1.453	0.163
		Post-test	20	2.000	0.000			
Theorizing, Analyzing and Solving Problems	Experimental	Pre-test	23	1.565	0.945	22	-1.686	0.106
		Post-test	23	2.000	0.797			
	Control	Pre-test	20	1.900	0.852	19	1.101	0.285
		Post-test	20	1.600	1.095			
Understanding Complex Information	Experimental	Pre-test	23	1.826	1.154	22	-4.685	0.000*
		Post-test	23	2.913	0.900			
	Control	Pre-test	20	1.850	0.933	19	-2.032	0.056
		Post-test	20	2.350	0.988			
Conceptual Understanding	Experimental	Pre-test	23	2.739	1.214	22	-1.468	0.156
		Post-test	23	3.217	1.380			
	Control	Pre-test	20	2.750	1.618	19	-0.170	0.867
		Post-test	20	2.800	1.005			
Factual Knowledge	Experimental	Pre-test	23	0.434	0.589	22	-3.272	0.003*
		Post-test	23	1.130	0.757			
	Control	Pre-test	20	0.850	0.812	19	-3.943	0.001*
		Post-test	20	1.450	0.604			
Reasoning and Analyzing	Experimental	Pre-test	23	0.695	0.875	22	-3.425	0.002*
		Post-test	23	1.217	0.671			
	Control	Pre-test	20	0.600	0.882	19	-1.157	0.262
		Post-test	20	0.850	0.875			
Applying	Experimental	Pre-test	23	1.826	0.886	22	0.000	1.000
		Post-test	23	1.826	0.834			
	Control	Pre-test	20	1.450	0.887	19	-0.237	0.815
		Post-test	20	1.500	1.000			
Knowledge	Experimental	Pre-test	23	0.347	0.486	22	-1.817	0.083
		Post-test	23	0.608	0.499			
	Control	Pre-test	20	0.350	0.489	19	-1.453	0.163
		Post-test	20	0.550	0.510			

*p<0.05

Table 6 compares the results obtained from the paired t-test of both the experimental and control groups. As can be seen from the table, there was a significant difference at the p=0.05 level between the pre- and post-test scores related to cognitive domains included understanding simple information, understanding complex information, factual knowledge, and reasoning and analyzing of the experimental group. However, no significant differences were found except the cognitive domain of factual knowledge between pre- and post-test scores of the control group. Interestingly, yet, a reduction in the mean of cognitive domain related to theorizing, analyzing and solving problems was found with post-test compared with pre-test.

Comparing the results obtained from both experimental and control group, it can be seen that teaching intervention, to some extent, had a meaningful effect on the experimental group students' achievement.

Is There Any Correlation Between the Scores of The Tsps And Achievement Test of the Experimental Group?

The Pearson Product Moment Correlation Coefficient (r) was calculated in order to determine whether any correlation existed between the scores of the TSPS and achievement test of the experimental students. According to the result, a significant positive correlation at the 0.05 level was found out (r=0.783) between the scores of TSPS and science achievement test.

Discussion & Conclusion

This study set out with the aim of examining the effects of the instructional intervention on the 7^{th} grade students' SPSs and science achievements. During the study, an instructional intervention was performed with a particular focus on the improvement of investigation skills.

Related to effects of the instructional intervention on the students' SPSs, contrary to expectations, this study did not find a significant difference between the experimental and control groups' post scores of SPSs. A possible explanation for this is that the new science and technology curriculum is based on student-centred approaches. However, when the means of the post-tests were examined, an increase in favour of the experimental group was established. Based on the evidence, it is possible to suggest that the instructional intervention, to some extent, had a positive effect on the experimental group. The results were consistent with the other studies emphasizing the importance of developing students' SPSs. For example, in a study carried out with 7^{th} grade students by Aktamış (2007), who provided the instructional intervention which was designed with closed, partial, and open-ended experimental activities respectively, although there was no meaningful difference between control and experimental groups, an increase of scientific process skills' using level was seen in favour of the experimental group. From the Table 3, we can express that the experimental group could more improve their SPSs than control group via the instructional intervention. The experimental group students used worksheets with scaffolding prompts that reminding them the mainly elements of doing investigation to guide their investigation. They had more opportunities to experience science process such as identifying a problem; choosing a research question; formulating hypothesis; determining and controlling variables; designing and conducting an experiment; collecting, recording and analysing data, and drawing conclusion through the instructional intervention over the study. The result of the study is supported by Metz (2004) who found that children could design and carry out their own investigations—posing questions, determining appropriate methods of inquiry, carrying out the study, and reporting and critiquing their own results with strong instructional guidance. In literature, many studies targeted developing SPSs have yielded positive impacts of the science process skills (e.g., Coil, Wenderoth, Cunningham, & Dirks 2010; Dirks & Cunningham 2006; Klahr & Chen, 2003; Spektor-Levy, Eylon, & Scherz, 2008; Wilke & Straits 2005;). Accordingly the results of their studies, the participants who were exposed to planned intervention could have significant benefits in the mastery of SPSs than the students who did not enrol in planned instruction, and the spontaneous attainment of any targeted process skill(s) may occur only to a limited extent. These results support the present study's findings about SPSs which might be improved gradually if it is well emphasized in courses.

Related to effects of the instructional intervention on the students' science achievement, this study found that there was no significant difference between the experimental and control groups' post scores of science achievement. However, when further analysis was performed of each cognitive domain for both experimental and control groups, the results obtained support the positive effect of the instructional intervention on the experimental group. As seen in Table 6, it is possible to assume that the instructional intervention has a greater contribution to the experimental students' science achievements related to cognitive domains of understanding simple information, understanding complex information, reasoning and analyzing, and theorizing, analyzing and solving problems. An intervention with emphasize on science process skills can have long-term positive effects on science achievement (Brotherton & Preece, 1996; Preece & Brotherton, 1997). Based on the literature, studies of instructional interventions carried out over weeks or months indicate that, with opportunities to practice or explicit instruction, even elementary and middle school children can master difficult concepts in science. However, to be successful, students need carefully structured experiences, scaffolded support from teachers, and opportunities for sustained engagement with the same set of ideas over extended periods of time (weeks, months, even years) (NRC, 2007, p. 338). Overreliance on textbooks may be cause to reduced opportunities for students to improve their SPSs.

On the question of whether there was any correlation between the scores of the TSPA and achievement in science of the students, a Pearson product moment correlation coefficient (r) was calculated to examine. The study found that there is a significant positive correlation (r=0.783) at the 0.05 level between the students' SPS and achievement scores. This study confirms that there is a positive relationship between the level of SPS and achievement of students (e.g., Aktamış, 2007; Aydoğdu, 2006; Shayer & Adey, 1993). Similarly, Güler (2010) found that there was a statistically significant correlation between 7th and 8th grades students' achievements on the Level Determination Exam (in Turkish SBS) and SPSs. It is assumed that students can learn knowledge of science while they learn how to design, set up, and carry out experiments and other kinds of scientific investigations. The starting point in considering any practical activity is its learning objective(s). The way a practical activity is designed and presented may have a significant influence on the extent to which its learning objective(s) is/are attained (Millar, 2010). In the light of the study's results, it is possible to suggest that using the methods which can improve students' SPSs should be continued insistently in order to increase science achievement of students.

There are several studies investigating teachers' views about implementations of the new science and technology curriculum in Turkey. According to the results, although the teachers claim that the new curriculum is more effective than the previous curriculum (e.g., Başdağ, 2006; Boyacı, 2010), activities are generally applied using a teacher-centred method because of many problems such as material and equipment shortage, lack of time, overcrowded classrooms, insufficient laboratory conditions, lack of teachers' knowledge, skills and experiences, and overloaded content in curricula (e.g., Kurtuluş & Çavdar, 2011). Baysen (2006) reported also, in general, teachers tend to ask knowledge level questions based on Bloom's taxonomy in their classes. As mentioned before, although the new science and technology curriculum was shifted from teacher-centred towards student-centred approaches as a result of the reform efforts, it can be suggested that the new curriculum does not sufficiently support inquiry-based teaching and learning approach. Many studies also stress the importance of a well-structured or scaffolded curriculum that leads students to adopt appropriate inquiry practices (McNeill, Lizotte, Krajcik, & Marx, 2006). Students need to have improved an appropriate level of SPS to conduct open-ended investigations. For this regards, the instructional intervention by emphasizing some aspects of science process can be seemed as a transition through inquiry-based elementary science and technology curriculum for their long-term educational success.

In this study, it is aimed to investigate whether the instructional intervention affects on improving process skills and achievement of science of the 7th grade students in Turkey. In this study, the difference between the experimental and control groups' the post-test scores of TSPA was no significant. Similarly, there was no significant effect of the treatment on the achievement. However, it can be possible suggest that the experimental group improved their SPSs and achievements more than the control group via the instructional intervention. As stated before, Turkish students are not familiar with inquiry-based learning approach. Hence, the results should be interpreted with transitional period to inquiry based science learning. Improving SPSs of students requires more time and long-term practicing. The study also indicated that there is a significant positive correlation between the students' SPSs and achievement in science. To sum, this study suggests that when science process are integrated into a science and technology course by giving a greater emphasis purposively, SPSs and achievements of students can be improved gradually over time.

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References

American Association for the Advancement of Science (AAAS, 1990). *Science for all Americans: Project 2061*. New York: Oxford University Press. Retrieved 10/01/2010, from http://www.project2061.org/publications/sfaa/online/chap14.html

Aktamış, H. (2007). *Fen eğitiminde bilimsel süreç becerilerinin bilimsel yaratıcılığa etkisi [The effects of scientific process skills on scientific creativity: the example of primary school seventh grade physics]*. Unpublished doctoral dissertation, Dokuz Eylül Universitesi, Eğitim Bilimleri Enstitüsü, Izmir, Turkey.

Aydoğdu, B. (2006). *İlköğretim fen ve teknoloji dersinde bilimsel süreç becerilerini etkileyen değişkenlerin belirlenmesi [Identification of variables effecting science process skills in primary science and technology course]*. Unpublished master's thesis, Dokuz Eylül Üniversitesi, Eğitim Bilimleri Enstitüsü, İzmir, Turkey.

Başdağ, G. (2006). *2000 yılı fen bilgisi dersi ve 2004 yılı fen ve teknoloji dersi öğretim programlarının bilimsel süreç becerileri yönünden karşılastırılması [To compare the science and technology curriculum of the 2004 with the science curriculum of the 2000 in their effects on developing the students' scientific process skills]*. Unpublished master's thesis, Gazi Universitesi, Eğitim Bilimleri Enstitüsü, Ankara, Turkey.

Baysen, E. (2006). Öğretmenlerin sınıfta sordukları sorular ile öğrencilerin bu sorulara verdikleri cevapların düzeyleri [The levels of teacher questıons and student answers], *Kastamonu Eğitim Dergisi. 14*(1), 21-28.

Berberoğlu, G., Arıkan, S., Demirtaşlı, N., İş Güzel, Ç., & Özgen Tuncer, Ç. (2009). İlköğretim 1.-5. sınıflar arasındaki öğretim programlarının kapsam ve öğrenme çıktıları açısından değerlendirilmesi. *Cito Eğitim: Kuram ve Uygulama*, *1*, 10-48.

Boyacı, K. (2010). *2005 ilkögretim 6. 7. ve 8. sınıf fen ve teknoloji öğretim programı, programın uygulanmasında yaşanan sorunlar ve çözüm önerilerine ilişkin öğretmen görüşleri [The problems of 6th, 7th and 8th grade science and technology education program in 2005 and teachers' opinions related to solution]*. Unpublished master's thesis, Cukurova Universitesi, Sosyal Bilimler Enstitüsü, Adana, Turkey.

Brotherton, P.N., & Preece, P.F.W. (1996). Teaching science process skills. *International Journal of Science Education, 18*, 65-74.

Coil, D., Wenderoth, M. P., Cunningham, M., & Dirks, C. (2010). Teaching the process of science: Faculty perceptions and an effective methodology. *CBE—Life Sciences Education, 9*, 524–535.

Department for Education Science (DfES) (2004). *Science: The National Curriculum for England*. London: DfEE. Retrieved 10/01/2012, from www.qca.org.uk/nc/

Dirks, C. & Cunningham, M. (2006). Enhancing diversity in science: Is teaching science process skills the answer? *CBE—Life Sciences Education,* 5 (3), 218–226.

ERG (Eğitim Reformu Girişimi) (2011). *Education monitoring report 2010: Execute summary 2010*, Istanbul, Turkey. Retrieved 10/01/2012, from http://erg.sabanciuniv.edu/sites/erg.sabanciuniv.edu/files/EIR_2010_Exe_Sum.pdf

Fraenkel, J. R. & Wallen, N. E. (2006). *How to design and evaluate research in education*. (6th ed.) New York: McGraw-Hill.

Germann, P. J. & Aram, R. J. (1996). Student performances on the science processes of recording data, analyzing data, drawing conclusions, and providing evidence. *Journal of Research in Science Teaching, 33*(7), 773-798.

Güler, Z. (2010). *İlköğretim öğrencilerinin SBS puanları ile ders başarıları, bilimsel süreç becerileri ve mantıksal düşünme yetenekleri arasındaki ilişki [The relationship among elementary students' test scores of level determination exam, course achievements, science processing skills and logical thinking skills]*. Unpublished master's thesis, Abant İzzet Baysal Üniversitesi, Sosyal Bilimler Enstitüsü, Bolu, Turkey.

Güneş, B. (Ed.). (2008). *İlkoğretim 7. sınıf fen ve teknoloji ders kitabı [7th grade science and technology textbook].*MEB Devlet Kitapları, Ankara: İmpress.

Hackling, M.W. (2005). *Working Scientifically: Implementing and Assessing Open Investigation Work is Science. A resources book for teachers of primary and secondary science.* Department of Education and Training, Western Australia. Retrieved 10/01/2012, from http://www.angelfire.com/sc/staws/Working_Scientifically.pdf

Klahr, D. & Chen, Z. (2003). Overcoming the positive-capture strategy in young children: learning about indeterminacy. *Child Development*, *September/October 2003, 74* (5), 1275-1296.

Kurtuluş, N. & Çavdar, O. (2011). Teachers' and students' views toward the activities of the primary science and technology curriculum. *Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education, 5* (1), 1-23.

McNeill, N.K., Lizotte, D.J., Krajcik, J., & Marx, R.W. (2004l). *Supporting students' construction of scientific explanations using scaffolded curriculum materials and assessments*. Paper presented at the annual meeting of the American Educational Research Association, San Diego, CA. Retrieved 15/02/2011, from http://hi-ce.org/aera2004.html

Metz, K.E. (2004). Children's understanding of scientific inquiry: Their conceptualization of uncertainty in investigations of their own design. *Cognition and Instruction*, *22*(2), 219-290.

Millar, R (2010). Increasing participation in science beyond GCSE: The impact of twentyfirst century science. *School Science Review*, *91*(337), 67–73.

Ministry of National Education [MoNE]. (2005). *İlköğretim fen ve teknoloji dersi (6, 7 ve 8. Sınıflar) öğretim program*ı. [*Elementary (6, 7, and 8th grade) Science and Technology Curriculum*) Talim Terbiye Kurulu Başkanlığı, Ankara.

NRC (National Research Council) (1996). *National science education standards*. Washington, D.C: National Academy Press.

NRC (National Research Council). (2007). *Taking science to school: Learning and teaching science in grades K-8*. R.A. Duschl, H.A. Schweingruber, & A.W. Shouse, (Eds). Committee on Science Learning-Kindergarten through Eighth Grade, The National Academies Press. Retrieved 10/01/2010, from: http://www.nap.edu/catalog/11625.html

Preece, P.F.W., & Brotherton, P.N. (1997). Teaching science process skills: Long-term effects on science achievement. *International Journal of Science Education, 19*, 895-901.

Shayer, M., & Adey, P. S. (1993). Accelerating the development of formal thinking in middle and high school students. IV: Three years after a two-year intervention*. Journal of Research in Science Teaching, 30*, 351-366.

Smith. K. A. & Welliver. P. W. (1995). *Science process assessments for elementary and middle school students. Smith and Welliver Educational Services.* Retrieved 10/01/2010, from

http://www.scienceprocesstests.com

Spektor-Levy, O., Eylon, B.S., & Scherz, Z. (2008). Teaching scientific communication skills in science studies: Does it make a difference? *Teaching and Teacher Education*, *24,* 462–477.

TIMSS (1999). TIMSS 1999 International science report: Findings from IEA's repeat of the third international mathematics and science study at the eighth grade. Retrieved 10/01/2010, from http://timss. bc.edu/timss1999i/science_achievement_report.html

TIMSS (2003). TIMSS 2007 International science report: Findings from IEA's trends in international mathematics and science study at the fourth and eighth grades. Retrieved 10/01/2010, from http://timss.bc.edu/TIMSS2003/PDF/TIMSS2003_InternationalScienceReport.pdf

TIMSS (2007). TIMSS 2007 International science report: Findings from IEA's trends in international mathematics and science study at the fourth and eighth grades. Retrieved 10/01/2010, from

http://timss.bc.edu/TIMSS2007/PDF/TIMSS2007_InternationalScienceReport.pdf

URL-1: http://timssandpirls.bc.edu

Wilke, R. R. & Straits, W.J. (2005). Practical advices for teaching inquiry-based science process skills in the biological sciences. *The American Biology Teacher*, *67*(9): 534-540.

APPENDIX A

Scaffolding for Variable-Based Investigative Work

Determine a problem on which you want to investigate (choose an experimental subject). --
Express the dependent variables (what is variable which you will observe or measure?). --
Express the independent variables (what is variable which you will investigate its effect?). --
Express the controlled variables (what factors/variables should be constant their effects?). --
Define your hypothesis that can be tested (what is your explanation about issue? What is possible relationship between dependent and independent variables?). --
Describe materials for your experiment (which materials do you need for experimental procedure?). 1- -- *2-* -- *3-* --
Design an experiment to test your hypothesis (which method do you carry out to test your hypothesis?). • *This procedure should include what will you observe or measure.* • *This procedure should include how will you observe or measure.* • *This procedure should include how many time will you repeat?*
Construct a data table (make sure to include column headings. Give each table a title and number).
Record your data in the table(s).
Draw graph(s) (if your data obtained appropriate to draw a graph and decide what type of graph is appropriate for your data. Give each graph a title and number. Make sure to scale all axes correctly).
Analyse your data and interpret your results (what do you know about the effect of the independent variable on the dependent variable? Do you see any relationship?). --
Write your conclusion (this is a respond statement for your research question). --
Write whether your hypothesis is supported or not. --
Express possible resources of error(s) --

APPENDIX B

Some of the Activities Intervened over the Study

Activity	Objectives of science content	Procedure		SPS Targeted
		Teacher provided	Students did	
Let's explore mixtures!	Explore differences of the mixtures; examine the concepts of mixtures such as heterogeneous, homogeneous, diluted, and concentrated	a scenario and materials	observation; comparison and classification; identification of similarities or differences; examinations some properties of mixtures; and exploration concepts such as diluted and concentrated	Observing; comparing and classifying; defining operationally; inferring
How temperature affect on the rate of dissolving?	Understand the effect of temperature on rate of dissolving	a scenario; a research question; materials; and a scaffolding by adapting from the study of Germann & Aram (1996).	revelation their own prior knowledge about content and procedure of science; development both conceptual and procedural knowledge and understanding of science	All of science process skills which are targeted by MoNE (2005)
How does the juice concentrated or diluted?	Explore how the solutions are diluted or concentrated	a scenario and invitation to open-ended investigate	understanding the process of problem solving.	All of science process skills which are targeted by MoNE (2005)
In the sun or in the shade?	Develop basic understanding of the relation between the angle of light rays and the temperature of a material	scaffolding for variable-based investigative work, a research question, hypothesis, dependent, independent and controlled variables, procedure, data table	first, discussion in their groups on each provided stage; next, set and conduct the experiment by paying attention to given instructions; record and analyse data; draw conclusion; exploration how an dependent variable changes when each of independent variables is changed; and getting in contact with daily life	Observing; comparing and classifying; Measuring; recording data; inferring and drawing conclusion
Effects of acid rains	Investigate the effects of acid rains	actual news titled of *dangerous of acid rain in Blacksea* from the *Milliyet newspaper on 14 December 2007*	a simple project; investigation; communicate scientifically (preparation and present of the poster)	Identifying a research question; hypothesizing; designing and conducting experiment; recording data; drawing conclusion; communicating