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Improving Pre-Service Teachers' Science Process Skills and Views about Scientific Inquiry*

Sınıf Öğretmen Adaylarının Bilimsel Süreç Becerilerinin ve Bilimsel Araştırma Hakkındaki Görüşlerinin Geliştirilmesi

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ABSTRACT: Despite the importance of scientific inquiry in science education, research has shown that pre-service teachers have deficiencies in terms of knowledge and skills. This study aimed to improve pre-service teachers' science process skills and views about scientific inquiry through inquiry-based activities. This study was carried out with one group pretest-posttest experimental design. A total of 41 (30 females, 11 males) pre-service teachers attending a classroom teaching program of a university in Turkey participated in this study. Within the scope of a science and technology laboratory course, scientific inquiry activities were carried out. As the data collection instruments, the Views about Scientific Inquiry (VASI) and the Scientific Process Skills Test (SPSt) were administered to the pre-service teachers before and after the implementation. In conclusion the pre-service teachers' views and skills about doing scientific inquiry developed. The findings were discussed in terms of the scientific process skills involved in scientific inquiry and the development of practical and theoretical aspects of scientific inquiry.

Keywords: Pre-service classroom teachers, the views about scientific inquiry (VASI), science process skills (SPS).

ÖZ: Fen eğitiminde bilimsel araştırmanın oldukça önemli bir yeri vardır. Bu öneme rağmen araştırma sonuçları öğretmen adaylarının bilimsel araştırma ile ilgili bilgi ve becerilerinde eksikliklerin olduğunu göstermiştir. Bu araştırmanın amacı sınıf öğretmen adaylarının bilimsel süreç becerilerinin ve bilimsel araştırmaya yönelik görüşlerinin bilimsel araştırmalar yardımı ile geliştirilmesidir. Tek grup öntest-sontest deneysel desende yürütülen bu araştırmaya Türkiye'de yer alan bir üniversitenin sınıf eğitimi anabilim dalında öğrenim gören toplam 41 (30 kadın, 11 erkek) öğretmen adayı katılmıştır. Fen ve teknoloji laboratuvarı dersi kapsamında bilimsel araştırma etkinlikleri gerçekleştirilmiştir. Veri toplama aracı olarak Bilimsel Araştırmaya Yönelik Görüş Anketi ve Bilimsel Süreç Becerileri Testi kullanılmıştır. Veri toplama araçları sürecin başında ve sonunda sınıf öğretmen adaylarına uygulanmıştır. Sonuç olarak öğretmen adaylarının bilimsel araştırmaya yönelik görüş ve bilimsel süreç becerilerinin bilimsel araştırmalar ile geliştiği görülmüştür. Sonuçlar bilimsel araştırma yapmanın beceri ve görüşü geliştirmesi konusunda teorik ve uygulamalı olarak tartışılmıştır.

Anahtar kelimeler: Sınıf öğretmen adayları, bilimsel araştırmaya yönelik görüş, bilimsel süreç becerileri (BSB).

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With the increasing emphasis on the constructive approach, reform movements have been undertaken in education programs in Turkey, leading to the adoption of inquiry-based learning in the science curriculum. In this sense, raising all students as scientific literacy regardless of their individual differences has become the main vision of science education programs. Scientific Process Skills (SPS) are considered to be one of the sub-dimensions of scientific literacy (Ministry of National Education [MoNE], 2006]. At the international level, one of the competences defined for scientific literacy is the design and evaluation of science inquiry methods [Organization for Economic Co-operation and Development [OECD], 2016]. Individuals need to have certain knowledge (Lederman et al., 2014) and skills (National Research Council [NRC], 2012) to engage in scientific inquiry. In a recent study conducted at the international level, it was reported that in Turkey, there were shortcomings in the teaching of scientific inquiry components (Lederman, Lederman, Bartels, & Jimenez, 2019).

Inquiry Based Learning and Scientific Inquiry

With the scientific and technological developments of the 1960s, student-centered approaches were abandoned and inquiry-based learning has taken its place in teaching programs (NRC, 1990). The basis of inquiry-based learning is constructivism, involving many cognitive and psychomotor processes, such as asking questions, developing hypotheses, collecting data, and conducting research (NRC, 2000). It can be applied in an open/full, guided, coupled, or structured manner according to the students' cognitive and grade levels (Martin-Hansen, 2002). The science curriculum of elementary education institutions, founded on inquiry-based learning, recommends structured inquiry activities in primary school, guided inquiry activities in the first year of the middle school, and open-ended inquiry activities in the last grade of the middle school (MoNE, 2013). Regardless of age and grade level, much practice should be undertaken to help students acquire the skills required for inquiry and to develop an aware of the stages in this process (Banchi & Bell, 2008, p. 26).

Inquiry-based learning enables students to actively develop their knowledge and skills and is based on constructivist theories (Piaget, 1971; Vygotsky, 1978). Although there are various inquiry-based learning cycles in the literature, the steps of this process can be generalized based on the results of previous research conducted. In this sense, the inquiry process starts with the introduction of an exploratory subject. In the conceptualization stage, the research question and hypothesis are determined. In addition, this stage involves the collection of the necessary information for the solution of the predefined problem. The research phase consists of preparing and implementing a plan to answer the research question, making observation, and collecting and interpreting data. In the final stage, theory is developed, solution suggestions are proposed, and a model is created. The last part, discussion, consists of communication and reflection that refer to the presentation and sharing of the research results and the factual explanation of the cases with evidence, respectively (Pedaste et al., 2015).

There is no consensus in the literature concerning what inquiry really means (Barrow, 2006; Lustick, 2009). It is used to refer to scientific inquiry, inquiry-based science teaching, discovery learning, learning as scientific inquiry, and learning science by inquiry (Dojman, 2003). From this point of view, if inquiry-based learning is a cluster, it can be claimed that scientific inquiry is a member of this cluster. Scientific inquiry is the whole of systematic research activities conducted by scientists to understand and explain the world (NRC, 2000). In the science curriculum last updated in Turkey in 2018, one of the main purposes of the program is given as adoption of a scientific inquiry approach in the process of discovering the natural world and understanding the relationship between human and environment in order to educate all individuals as science literates (MoNE, 2018). The scientific inquiry process involves asking questions regarding the subject to be researched, planning and implementing research, thinking mathematically, analyzing and interpreting data, and using communication skills (NRC, 2012).

Views about Scientific Inquiry

Scientific inquiry is the most fundamental part of science courses providing permanent learning and concretizing abstract concepts. In order to raise scientifically literate individuals, from preschool to postgraduate education, students' views of scientific inquiry are important to determine their knowledge and skills, understand the current situation, and eliminate any incompetence (Strippel & Sommer, 2015). In this sense, there is a need for valid and reliable measurement tools related to scientific inquiry skills and the nature of scientific inquiry. However, for this purpose, in the literature is the views of scientific inquiry (VOSI) and the views about scientific inquiry (VASI) questionnaire developed (Lederman, et al., 2014; Schwartz, Lederman, & Leerman, 2008).

Using VASI, it is possible to evaluate the eight components of the nature of scientific inquiry. The first component is related to the fact that all scientific inquiry begins with a question but does not require a hypothesis. The second component refers to there being more than one method to conduct scientific inquiry, the third is related to research questions guiding the research process, the fourth specifies that scientists using the same process may not reach the same results, the fifth is associated with the research process having an effect on the results, the sixth concerns data and evidence not being the same phenomena, the seventh refers to the requirement of consistency between the collected research findings, and the last component is about arriving at scientific explanations by combining the data collected and what is previously known (Lederman et al., 2014). The VOSI and VASI have been used to investigate levels of middle school (Senler, 2015; Yang, Park, Shin, & Lim, 2017), high school (Anggraeni, Adisendjaja, & Amprasto, 2017; Leblebicioğlu, Çapkınoğlu, Metin, & Schwartz, 2017), university (Gaigher, Lederman, & Lederman, 2014), and of the teachers (Adisendjaja, Rustaman, Redjeki, & Satori, 2017; Bartos & Lederman, 2014). One common conclusion of these studies is that in-service and pre-service teachers and students do not have an adequate level of views concerning the nature of science and scientific inquiry.

Science Process Skills (SPS)

SPS has existed in the education literature for a long time (Padilla, Okey, & Garrard, 1984). The emphasis of SPS in current education programs indicates that it remains equally important (Australian Curriculum, Assessment, and Reporting Authority (ACARA), 2012; MoNE, 2018; NRC, 2012). Some sources refer to SPS as scientific reasoning competencies, scientific inquiry skills, and science skills (Kruit, Oostdam, Berg, & Schuitema, 2018). SPS can also be defined as the skills used by scientists to conduct scientific research. Although there are different classifications in the literature, these skills are generally related to observation, classification, communication, measuring, using space/time relations, using numbers, making inferences, estimating, changing and controlling variables, hypothesizing, interpreting data, operational definition, and experimentation (Ayas, Çepni, Johnson, & Turgut, 1997; Padilla, Okey, & Garrard, 1984). Among these, observation, classification, communication, and measurement are basic skills, while controlling variables, constructing hypotheses, interpreting data, operational identification and experimentation are high-level. When the cognitive development levels of the students are taken into consideration, it is necessary to help them acquire basic skills during preschool and primary school and higher-level skills from the secondary school onwards. This research covered the integrated process skills of defining variables, operational definition, hypothesizing, interpreting charts and data, and experimentation. It is very important to determine the variables to be investigated in research. A variable may have qualitative or quantitative values, but it also represents the changing properties of an object of event. An independent variable is a type of variable that can be changed according to the researcher's request while a dependent variable is affected by an independent variable or variables. The control variable is kept constant throughout the research process to prevent any effect on the dependent variable. Operational definition means that students create their own definitions in accordance with the information obtained from their own experience and observations instead of memorizing the formal definitions of concepts. A hypothesis is a proposition that has not been tested for accuracy or inaccuracy. Hypotheses guide scientists about what additional data are needed to interpret the data obtained during the research process and what data they should focus on. In the interpretation of the data, first, the information to be accessed should be determined. The decision-making process depends on the predefined hypotheses. Converting the data collected in line with hypotheses into visual forms (graphics, tables) using tools, such as computers and calculators makes it easier to interpret the data. Designing and conducting experiments that require students to apply all scientific process skills constitute the broadest part of the research process (Çepni, 2005).

The best place to develop SPS is a laboratory (Hofstein & Mamlok-Naaman, 2007), and the most effective approach for the development of SPS is inquiry-based learning (Yıldırım, Çalık, & Özmen, 2016). In this regard, research conducted with middle school students showed that guided inquiry-based learning had positive contributions to their cognitive and affective domains and improved their attitudes, achievements and SPS (Köksal & Berberoğlu, 2014). The training of teacher candidates and teachers in relation to SPS is another important issue. In recent years, however, a study undertaken with science teachers revealed that their conceptual understanding of SPS was poorer compared to practice. Researchers attributed this to the teaching characteristics and conditions of teachers (Shahali, Halim, Treagust, Won, & Chandrasegaran, 2017). In another study conducted with university students, a significant relationship was observed between SPS and success (Feyzioglu, 2009).

Aim of This Study

Developing the science process skills and views about pre-service teachers about scientific inquiry is important for their future students. Due to the literature lacking research concerning the effect of scientific inquiry activities on the students' SPS and views about scientific inquiry, the results of the current study are expected to act as a guide for further research and offer ideas about possible implementations. The aim of this research was to improve the SPS of pre-service teachers through scientific inquiry activities. For this purpose, the research problems are as follows:

(1) What is the effect of science inquiry activities on pre-service teachers' SPS?

(2) What is the effect of science inquiry activities on pre-service teachers' views about scientific inquiry?

Method

This research was carried out with a single sample group to examine the effect of scientific inquiry undertaken within the scope of the Science and Technology I Laboratory course on pre-service science teachers' SPS and views about scientific inquiry. In the one-group experimental design, the effect of the experimental procedure on a single group is tested through research. The measurements of the dependent variable are obtained using the same instrument administered to the same subjects before and after the implementation as pre-test and post-test, respectively. Random assignment and group matching are not used (Fraenkel & Wallen, 2003). This study was conducted on a single group without experimental and control groups because the development of scientific process skills and views of all pre-service teachers participating in the research were considered important. Raising knowledgeable prospective teachers is very important for the development of their own pedagogical and field knowledge, as well as that of their future students. On the other hand ethical rules were followed in this research.

Study Group

This study was conducted with pre-service teacher attending the second grade of a classroom teaching program in the Education Faculty of a university located in the Central Anatolia Region of Turkey. A total of 41 pre-service teachers (30 females, 11 males) participated in the study. The mean age of the pre-service teachers was 20 years. In Turkey, student placement in universities is based on the scores from a central test. For the enrollment in classroom teaching programs, Turkish and mathematics scores are taken into consideration. In these programs, students take physics, chemistry and biology courses, but their academic level is generally poor regarding these subjects. In this study, the researcher chose a situation that is close to her and easy to access. In this sense convenience sampling technique was used. This research was carried out on pre-service teachers studying in the second grade because the Science and Technology I Laboratory course is taught in the second grade. Since this course is practical, it is thought that it will enable the development of scientific process skills and the views about scientific inquiry.

Data Collection Tools

SPS test. SPS test was developed by Burns, Okey, and Wise (1985). Geban, Aşkar, and Özkan (1992) adapted SPS test to Turkish. In this study it was used as a pre- and post-test to determine the level of SPS of the participant pre-service teachers. This test consists of 34 multiple choice questions that evaluate the respondents' skills related to defining variables (12 question), operational definition (six questions), hypothesizing (nine questions), interpreting charts and data (six questions), and experimentation (three questions). Since this test was designed to evaluate the development of high-level cognitive process skills, it was considered appropriate to use it to measure the level of integrated process skills of pre-service teachers. The measurement reliability of the test was calculated as 0.79. The participants' correct and incorrect responses in the SPS test were coded as '1' and '0', respectively.

VASI. In order to determine the changes in the pre-service teachers' views about scientific inquiry through the implementation of the program, this questionnaire, developed by Lederman et al. (2014) and adapted to Turkish by Karısan, Bilican, and Senler (2017), was administered to the participants. This tool consisted of seven items related to eight components of scientific inquiry. These components are (Lederman, et al., 2014):

(F1) Scientific investigations all begin with a question, but do not necessarily test a hypothesis

(F2) There is no single set or sequence of steps followed in all investigations

(F3) Inquiry procedures are guided by the question posed

(F4) All scientists performing the same procedures may not obtain the same results

(F5) Inquiry procedures can influence results

(F6) Scientific data are not the same as scientific evidence

(F7) Research conclusions must be consistent with the data collected

(F8) Explanations are developed from a combination of collected data and what is already known

Data Collection Procedures

The research data were collected within the scope of the Science and Technology Laboratory I course in the fall semester of 2018-2019 academic year. In this research, researcher and lecturer are the same person. The implementation process took a total of 14 hours over seven weeks. Table 1 presents the details of this process.

Table 1

Implementation Process

Week	Scientific inquiry activities and other procedures
1	Administration of VASI and SPS test as pre-test, PowerPoint presentation on SPS and scientific inquiry
2	Performing measurements with a dynamometer

3	State of materials with different masses in water
4	Heat conduction
5	Effect of resistance on the brightness of bulbs
6	Expansion using Gravesande's ball and ring experiment
7	Administration of VASI and SPS test as post-test

The SPS test and VASI were administered to the pre-service teachers as pre-tests in week one, and the participants were asked to respond to the questions honestly. After the application of the data collection tools, the lecturer gave a PowerPoint presentation about the basic and unified process skills and the features of scientific inquiry by providing relevant examples. In the second week, the pre-service teachers performed measurements using dynamometry and slotted weights. The third week concerned the measurement of the density of different objects with the same volume but varying masses. In the fourth week, the pre-service teachers observed the conduction of heat in different metals using a heat conductor. The fifth week was related to the determination of the effect of resistance on the brightness of ampoule using a rheostat. In the sixth week, the pre-service teachers investigated the effect of heat on expansion using Gravesande's ball and ring experiment, and in the last week, they completed the SPS test and VASI as post-tests. The pre-service teachers performed all the activities in groups of five or six, but prepared an individual report for each scientific inquiry activity performed. The scientific inquiry reports were related to basic concepts (theoretical framework), research problems, variables (dependent, independent, fixed), implementation of research, results and interpretation, and SPS used in the scientific inquiry process. The activities in the second week were structured, and all activities undertaken in the following weeks were guided.

During the research process, the pre-service teachers were asked to prepare reports for each scientific inquiry activity undertaken during the science and technology laboratory I course in order to improve their scientific process skills. In this process, the pre-service teacher's collected theoretical information before attending each scientific inquiry activity presented in Table 1 and included this in their reports. During the class hour, they determined the problems and variables of each scientific inquiry, carried out scientific inquiry, recorded the results of the research by creating graphs and tables, and interpreted the results. Finally, they explained the scientific process skills used in each scientific inquiry in their reports. This aimed to increase the awareness of the pre-service teachers about the scientific process skills they used and the way they used them. In the process of conducting scientific inquiry, the pre-service teachers were free to choose the paths to follow. In addition, each group was asked to compare the results of their research and interpret the reasons for the differences, if any. Table 2 presents the list of activities undertaken before and during the science and technology laboratory I course.

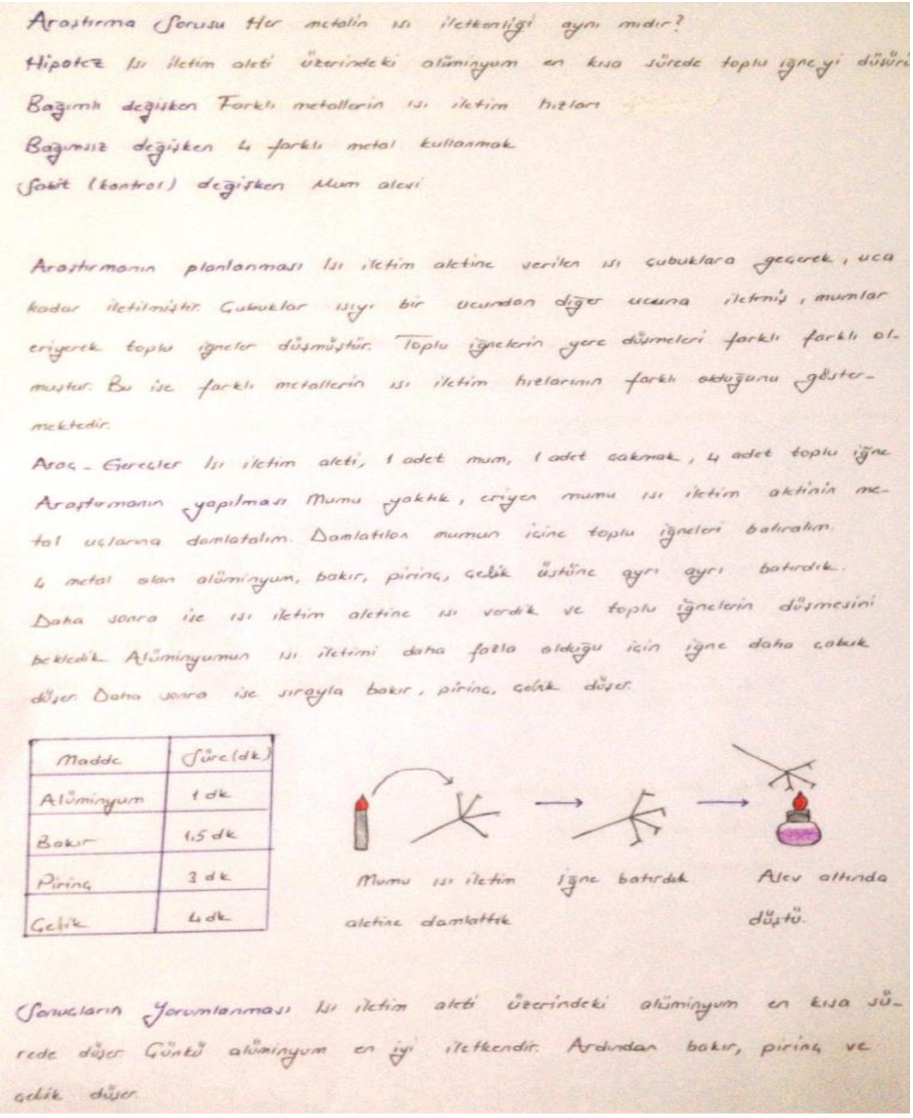
Table 2

Activities Undertaken before and during the Science and Technology Laboratory I Course

Before coming science and technology laboratory I course	Collecting and reporting theoretical information about the scientific inquiry to be conducted
During science and technology laboratory I course	Scientific inquiry cycle - Defining the problem - Hypothesizing - Defining the variables (dependent, independent, fixed) - Choosing the research method to test the hypothesis - Conducting the scientific inquiry - Reporting the results of scientific inquiry - Interpreting the results - Comparing the results of different groups

The scientific inquiry report of a preservice teacher is shown in Figure 1 below.

Figure 1. Example of a Preservice Teachers' Scientific İnquiry Report (Heat Conduction)


Araştırma Sorusu Her metalin ısı iletkenliği aynı mıdır?
Hipotez Isı iletim aleti üzerindeki alüminyum en kısa sürede toplu iğneyi düşür
Bağımlı değişken Farklı metallerin ısı iletim hızları
Bağımsız değişken 4 farklı metal kullanmak
Sabit (kontrol) değişken Mum alevi

Araştırmanın planlanması Isı iletim aletine verilen ısı çubuklara geçerek, uca kadar iletilmiştir. Çubuklar ısıyı bir ucundan diğer ucuna iletmiş, mumlar eriyerek toplu iğneler düşmüştür. Toplu iğnelerin yere düşmeleri farklı farklı olmuştur. Bu ise farklı metallerin ısı iletim hızlarının farklı olduğunu göstermektedir.
Araç - Gereçler Isı iletim aleti, 1 adet mum, 1 adet çakmak, 4 adet toplu iğne
Araştırmanın yapılması Mumu yaktık, eriyen mumu ısı iletim aletinin metal uçlarına damlatalım. Damlatılan mumun içine toplu iğneleri batıralım. 4 metal olan alüminyum, bakır, pirinç, çelik üstüne ayrı ayrı batırdık. Daha sonra ise ısı iletim aletine ısı verdik ve toplu iğnelerin düşmesini bekledik. Alüminyumun ısı iletimi daha fazla olduğu için iğne daha çabuk düşer. Daha sonra ise sırayla bakır, pirinç, çelik düşer.

Madde	Süre (dk)
Alüminyum	1 dk
Bakır	1,5 dk
Pirinç	3 dk
Çelik	4 dk

Sonuçların Yorumlanması Isı iletim aleti üzerindeki alüminyum en kısa sürede düşer. Çünkü alüminyum en iyi iletkendir. Ardından bakır, pirinç ve çelik düşer.

This scientific inquiry is about the effect of different metals on thermal conductivity.

In the report of the preservice teacher, there are parts of the research question, variables, research plan, necessary tools and equipment, the conduct of the research, the related table and the interpretation of the figures and results.

Data Analysis

SPSS software v. 21 was used to analyze the data. Statistical analysis was carried out on the data collected from 41 pre-service teachers. The normality of quantitative data was examined based on skewness and kurtosis values using the Kolmogorov-Smirnov test. Since the data were found to have normal distribution, the paired samples t-test was used for the whole SPS test and its sub-dimensions administered as pre- and post-tests.

The qualitative data (VASI) was evaluated by content analysis. In this process, two researchers conducted analysis and reached an agreement by discussing where there were differences of opinion. Using VASI, the views of pre-service teachers were categorized as “unclear/no response”, “naive”, “complex”, and “informed”. These categories are numbered as 1, 2, 3 and 4 respectively. Since the pre-service teachers' VASI scores were not normally distributed, the Wilcoxon signed-ranks test was used.

Results

Findings about the First Research Question

Table 3 presents the comparative results of the participants' SPS pre- and post-test mean scores.

Table 3

Paired Samples T-Test Results of Pre-Service Teachers' SPS Scores

SPS factors	Pre-test		Post-test				
	M	SD	M	SD	t	p	η^2
Defining variables	4.95	2.09	6.25	1.9	3.04	.00	.18
Operational definition	3.63	1.44	4.02	1.66	1.94	.05	.08
Hypothesizing	6.17	1.13	6.53	1.02	2.1	.04	.09
Interpreting chart and data	4.68	.81	4.97	.75	2.08	.04	.09
Experimentation	2.33	.66	2.53	.59	1.31	.19	.04
Total SPS test scores	21.82	3.38	24.32	3.06	5.2	.00	.4

According to the paired-samples t-test, the pre-service teachers' showed a development in their positive scores for three factors: defining variables $t(40)=3.04$, $p<.05$, $\eta^2=.18$, hypothesizing $t(40)=2.1$, $p<.05$, $\eta^2=.09$, and interpreting charts and data $t(40)=2.08$, $p<.05$, $\eta^2=.09$, as well as the total SPS test scores $t(40)=5.2$, $p<.05$, $\eta^2=.4$. There was no significant difference between the pre-service teachers' scores related to operational definition $t(40)=1.94$, $p>.05$, $\eta^2=.08$ and experimentation $t(40)=.3$, $p>.05$, $\eta^2=.04$ after the implementation of the program. Despite the absence of a significant difference between the SPS pre-test and post-test results, there was an increase in the participants' mean scores related to “operational definition” and “experimentation” sub-dimensions of the test.

Findings about the Second Research Question

A comparison of the pre-test and post-test VASI scores of the pre-service teachers' is shown in Table 4.

Table 4
Wilcoxon Signed-Ranks Test Results of the Pre-Service Teachers' VASI-N Scores

Test statistics	F1	F2	F3	F4	F5	F6	F7	F8
z	2.64	2.41	.41	2.65	.36	.06	2.77	1.00
p	.00	.01	.68	.00	.71	.95	.00	.31
Negative rank (mean rank)	.00	5.75	3	7	8.42	5.5	16.5	.00
Negative rank (sum of ranks)	.00	11.5	6	28	50.5	22	33	.00
Positive rank (mean rank)	4.5	7.23	3	10.21	5.79	4.6	9.83	1
Positive rank (sum of ranks)	36	79.5	9	143	40.5	23	177	1
Mean of pre-test	3.24	2.44	3.66	2.95	2.68	2.59	2.98	3.63
Mean of post-test	3.49	2.85	3.71	3.44	2.69	2.61	3.46	3.71

The analysis of the data obtained from the pre-test and post-test VASI revealed a positive change in the pre-service teachers' views about the components of scientific inquiry, namely "(F1) Scientific investigations all begin with a question, but do not necessarily test a hypothesis (z=2.64, p<.05)", "(F2) There is no single set or sequence of steps followed in all investigations (z=2.41, p<.05)", "(F4) All scientists performing the same procedures may not obtain the same results (z=2.65, p<.05)", and, "(F7) Research conclusions must be consistent with the data collected (z=2.77, p<.05)" components of scientific inquiry, while no significant difference was observed concerning the "(F3) Inquiry procedures are guided by the question posed (z=.41, p>.05)", "(F5) Inquiry procedures can influence results (z=.36, p>.05)", "(F6) Scientific data are not the same as scientific evidence (z=.06, p<.05)" and, "(F8) Explanations are developed from a combination of collected data and what is already known (z=1, p>.05)".

There was an increase in the participants' mean scores in the scientific inquiry components of "(F3) Inquiry procedures are guided by the question posed", "(F5) Inquiry procedures can influence results", "(F6) Scientific data are not the same as scientific evidence" and, "(F8) Explanations are developed from a combination of collected data and what is already known", but no significant difference was observed between the pre-test and post-test results.

Discussion and Conclusion

The current study, which aimed to develop pre-service teachers' scientific process skills and views science inquiry, revealed that the pre-service teachers' knowledge and skills concerning undertaken scientific inquiry developed. In this regard, scientific inquiry inquiry conducted with classroom teaching students in the science and technology laboratory course made positive contributions to the targeted student outputs.

The results of the research revealed a significant relationship between the total SPS test scores and defining the variables, hypothesizing, and interpreting charts and data. There was no significant difference between the pre-service teachers' scores related to operational definition and experimentation after the implementation of the program. This finding is considered to be due to students being familiar with experimentation and operational definition from their learning history. On the other hand, there was an increase in the mean scores in the "operational definition" and "experimentation" components of the SPS test, despite the absence of a significant difference before and after the implementation. Based on these results, it can be argued that scientific inquiry carried out within the scope of this research had a positive effect on the SPS of the pre-service teachers. In the literature, it is suggested that student-centered inquiry-based learning is the most effective approach for the development of SPS (Köksal & Berberoğlu, 2014; Yıldırım, Çalık, & Özmen, 2016). Thus, the SPS findings of the current study are consistent with the literature. In addition, the reason why the pre-service teachers' operational definition skills did not show any significant difference during the research; i.e., why it was not developed through engaging in scientific inquiry, may be related to the theoretical background of this dimension. Furthermore, the lack of a statistical difference in the experimentation skills can be attributed to the pre-service teachers' familiarity with and previous experience of conducting experiments.

There are some points that should be taken into consideration by practitioners in the development of SPS through scientific inquiry. At this point, it should be noted that among teacher-centered practices, guided inquiry is a transitional process (Köksal & Berberoğlu, 2014). Another important issue is the training of in-service and pre-service teachers about SPS, ensuring that they correctly understand SPS in both conceptual and practical terms (Shahali, Halim, Treagust, Won, & Chandrasegaran, 2017). Theoretical and practical activities to be carried out for this purpose will initiate a positive change in the SPS of teachers (Dailey & Robinson, 2017).

According to the results, a significant difference was found in the pre-service teachers' views related to four components of scientific inquiry in favor of post-test scores (F1, F2, F4, F7). Furthermore, compared to the pre-test results, there was an increase in the post-test mean scores of the components, "inquiry procedures are guided by the question posed", "inquiry procedures can influence results", "scientific data are not the same as scientific evidence" and, "explanations are developed from a combination of collected data and what is already known albeit without significance. As a result of the research, it is considered that the sub-dimensions that differed in the pre-service teachers' views about scientific inquiry are more concerned with conducting scientific inquiry, whereas those with no significant difference are more related to the theoretical sub-structure of scientific inquiry. On the other hand, as explained in the data collection process, it was observed that the pre-service teachers developed aspects emphasized in the science and technology laboratory I course.

According to the results, it can be suggested that scientific inquiry carried out within the scope of the research had a positive effect on the pre-service teachers' views about scientific inquiry. This is consistent with the relevant literature concerning the improvement of scientific inquiry views through scientific research or related activities. For example, Adisendjaja, Rustaman, Redjeki, and Satori (2017) concluded that the teachers' views on scientific inquiry improved after implementing a program on the nature of science and scientific inquiry. Some of the recent research results also revealed that open-ended inquiry-based learning developed views of scientific inquiry (Testa, Zappia, & Galano, 2017). In another study, it was observed that the students had enhanced views on scientific inquiry following two-week hands-on experiences in a summer camp (Antink-Meyer, Bartos, Lederman, & Lederman, 2016).

There are some points to be considered when conducting scientific inquiry in educational environments. For instance, to develop knowledge and skills related to scientific inquiry, it is necessary to understand related basic concepts, such as data and evidence (Yang, Park, Shin, & Lim, 2017). These basic concepts and components of scientific research should be integrated into the activities performed. Integration of targeted concepts with clear and reflective scientific inquiry can improve students' view of scientific inquiry (Tirre, Kampschulte, Thoma, Höffler, & Parchmann, 2019).

Limitations and Suggestions for Future Research

The results of the study showed that the pre-service teachers' skills and views related to scientific inquiry had positively improved. However, this study had certain limitations, such as the one-group experimental design and the absence of a control group. Although standardized data collection tools were used that had previously been proven valid and reliable, the research was limited to these tools and the sample size used. Furthermore, when evaluating the findings of the research, it should be taken into consideration that the study group consisted of pre-service classroom teachers for whom science is generally not a strong suit.

In future studies, student reports on scientific inquiry activities conducted in classroom or laboratory environments can be qualitatively evaluated, and development of students' scientific inquiry skills and views on scientific inquiry can be examined during this process. In addition, the development of participants' conceptualization can be examined. Different methods and techniques can be used to improve the views and skills of teachers and prospective teachers. Additional activities can be developed for the knowledge and skills that do not show improvement within the scope of the research.

References

Adisendjaja, Y. H., Rustaman, N. Y., Redjeki, S., & Satori, D. (2017). Science teachers' understanding of scientific inquiry in teacher professional development. *Journal of Physics: Conference Series, 812:* 012054.

Anggraeni, N., Adisendjaja, Y. H., & Amprasto, A. (2017). Profile of high school students' understanding of scientific inquiry. *Journal of Physics: Conference Series, 895,* 1-5.

Antink-Meyer, A., Bartos, S., Lederman, J. S., & Lederman, N. G. (2016). Using science camps to develop understandings about scientific inquiry-Taiwanese students in U.S. summer science camp. *International Journal of Science and Mathematics Education, 14*(1), 29-53.

Australian Curriculum, Assessment, and Reporting Authority (ACARA). (2012). *Australian curriculum: science. Sydney: Australian Curriculum, Assessment, and Reporting Authority*.

Ayas, A., Çepni, S., Johnson, D., & Turgut, M. F. (1997). *Kimya öğretimi, öğretmen eğitimi dizisi [Chemistry teaching, teacher training series].* YÖK Dünya Bankası Milli Eğitimi Geliştirme Projesi Yayınları, Bilkent, Ankara.

Banchi, H., & Bell, R. (2008). The many levels of inquiry. *Science and Children, 46*(2), 26-29.

Barrow, L. H. (2006). A brief history of inquiry: From Dewey to standards. *Journal of Science Teacher Education, 17,* 265-278.

Bartos, S. A., & Lederman, N. G. (2014). Teachers' knowledge structures for nature of science and scientific inquiry: Conceptions and classroom practice. *Journal of Research in Science Teaching, 51*(9), 1150-1184.

Burns, J. C., Okey J. R., & Wise, K. C. (1985). Development of an integrated process skill test: TIPS II. *Journal of Research in Science Teaching, 22*(2), 169-177.

Çepni, S. (2005). *Kuramdan uygulamaya fen ve teknoloji öğretimi [Science and technology teaching from theory to practice].* Ankara: Pegem A.

Dailey, D., & Robinson, A. (2017). Improving and sustaining elementary teachers' science teaching perceptions and process skills: A postintervention study. *Journal of Science Teacher Education, 28*(2), 169-185.

Dojman, H. N. (2003). *An analysis of elementary teachers' perceptions of teaching science as inquiry* (Doctoral Dissertation). The Faculty of the College of Education University of Houston, Texas.

Feyzioglu, B. (2009). An investigation of the relationship between science process skills with efficient laboratory use and science achievement in chemistry education. *Journal of Turkish Science Education, 6,* 114-132.

Fraenkel, J. R., & Wallen, N. E. (2003). *How to design and evaluate in education.* New York: McGraw-Hill Higher Education.

Gaigher, E., Lederman, N., & Lederman, J. (2014). Knowledge about inquiry: a study in South African high schools. *International Journal of Science Education, 36*(18), 3125-3147.

Geban, Ö., Aşkar, P., & Özkan, D. (1992). Effects of computer simulations and problem-solving approaches on high school students. *Journal of Educational Research, 86*(1), 5-10.

Hofstein, A., & Mamlok-Naaman, R. (2007). The laboratory in science education: the state of the art. *Chemistry Education: Research and Practice in Europe, 8*(2), 105-108.

Karısan, D., Bilican, K., & Senler, B. (2017). The adaptation of the views about scientific inquiry questionnaire: a validity and reliability study. *Inonu University Journal of the Faculty of Education, 18*(1), 326-343.

Kruit, P. M., Oostdam, R. J., Berg, E., & Schuitema, J. A. (2018) Assessing students' ability in performing scientific inquiry: instruments for measuring science skills in primary education. *Research in Science & Technological Education, 36(*4), 413-439.

Köksal, A. E., & Berberoğlu, G. (2014). The effect of guided- inquiry instruction on 6th grade Turkish students' achievement, science process skills, and attitudes toward science. *International Journal of Science Education, 36*(1), 66-78.

Leblebicioğlu, G., Çapkınoğlu, E., Metin, D., & Schwartz, R. (2017). *Views of nature of scientific inquiry of the students in a science high school in Turkey: a vasi application.* Paper presented at European Science Education Research Association, ESERA.

Lederman, J., Lederman, N., Bartels, S., & Jimenez, J. (2019). An international collaborative investigation of beginning seventh grade students' understandings of scientific inquiry: Establishing a baseline. *Journal of Research in Science Teaching, 56*(4), 1-30.

Lederman, J. S., Lederman, N. G., Bartos, S. A., Bartels, S. L., Meyer, A. A., & Schwartz, R. S. (2014). Meaningful assessment of learners' understandings about scientific inquiry-The views about scientific inquiry (VASI) questionnaire. *Journal of Research in Science Teaching, 51*(1), 65-83.

Lustick, D. (2009). The failure of inquiry: preparing science teachers with an authentic investigation. *Journal of Science Teacher Education, 20,* 583-604.

Martin-Hansen, L. (2002). Defining inquiry. *The Science Teacher, 69*(2), 34-37.

Ministry of National Education (MoNE). (2006). İlköğretim kurumları (ilkokullar ve ortaokullar) fen bilimleri dersi (3, 4, 5, 6, 7 ve 8. sınıflar) öğretim programı *[Foundational education institutions (3, 4, 5, 6, 7, and 8th grades) science curriculum]*. Ankara: MEB.

Ministry of National Education (MoNE). (2013). *İlköğretim kurumları (ilkokullar ve ortaokullar) fen bilimleri dersi (3, 4, 5, 6, 7 ve 8. sınıflar) öğretim programı [Foundational education institutions (3, 4, 5, 6, 7, and 8th grades) science curriculum].* Ankara: Talim ve Terbiye Kurulu Başkanlığı.

Ministry of National Education (MoNE). (2018). *İlköğretim kurumları (ilkokullar ve ortaokullar) fen bilimleri dersi (3, 4, 5, 6, 7 ve 8. sınıflar) öğretim programı [Foundational education institutions (3, 4, 5, 6, 7, and 8th grades) science curriculum]. Ankara: Talim ve Terbiye Kurulu Başkanlığı.*

National Research Council (NRC). (1990). *Reports of the committee on vision: 1947-1990.* Washington, DC: The National Academies Press.

National Research Council (NRC). (2000). *Inquiry and the national science education standards.* Washington, DC: National Academy Press.

National Research Council (NRC). (2012*). A framework for K-12 science education: Practices, crosscutting concepts and core ideas.* Washington, DC: National Academy Press.

Organisation for Economic Co-operation and Development (OECD). (2016). *PISA 2015 assessment and analytical framework: science, reading, mathematic and financial literacy.* Paris: PISA, OECD Publishing.

Padilla, M. J., Okey, J. R., & Garrard, K. (1984). The effects of instruction on integrated science process skill achievement. *Journal of Research in Science Teaching*, *21*(3), 227-287.

Pedaste, M., Mäeots, M., Siiman, L. A., de Jong, T., van Riesen, S. A. N., Kamp, E. T., et al. (2015). Phases of inquiry-based learning: Definitions and the inquiry cycle. *Educational Research Review, 14*, 47-61.

Piaget, J. (1971). The theory of stages in cognitive development. In D. R. Green, M. P. Ford, & G. B. Flamer (Eds.), *Measurement and Piaget*. McGraw-Hill.

Schwartz, R. S., Lederman, N., & Lederman, N. (2008, March). *An instrument to assess views of scientific inquiry: The VOSI questionnaire.* Paper presented at the international conference of the. Baltimore, MD.

Shahali, E. H. M., Halim, L., Treagust, D. F., Won, M., & Chandrasegaran, A. L. (2017). Primary school teachers' understanding of science process skills in relation to their teaching qualifications and teaching experience. *Research in Science Education, 47,* 257-281.

Senler, B. (2015). Middle school students' views of scientific inquiry: an international comparative study. *Science Education International, 26*(2), 166-179.

Strippel, C., & Sommer, K. (2015). Teaching nature of scientific inquiry in chemistry: how do German chemistry teachers use labwork to teach NOSI? *International Journal of Science Education, 37*(18), 2965-2989.

Testa, I., Zappia, A., & Galano, S. (2017). *Improving students' views about scientific inquiry through explicit teaching: a rasch-based analysis.* Paper presented at European Science Education Research Association, ESERA.

Tirre, F., Kampschulte, L., Thoma, G-B., Höffler, T., & Parchmann, I. (2019). Design of a student lab program for nanoscience and technology – an intervention study on students' perceptions of the nature of science, the nature of scientists and the nature of scientific inquiry. *Research in Science & Technological Education*, *37*(4), 393-418.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

Yang, I. H., Park, S. W., Shin, J. Y., & Lim, S. M. (2017). Exploring Korean middle school students' view about scientific inquiry. *Eurasia Journal of Mathematics Science and Technology Education, 13*(7), 3935-3958.

Yıldırım, M., Çalık, M., & Özmen, H. (2016). A meta-synthesis of Turkish studies in science process skills. *International Journal of Environmental & Science Education, 11*(14), 6518-6539.