EXPERIENCED CHEMISTRY TEACHERS' SCIENCE PROCESS SKILLS (SPSs) DEVELOPMENT AND THEIR USE OF SPSs IN ACTIVITY PLANS

Sevgi AYDIN-GÜNBATAR
Department of Mathematics and Science Education
Van Yuzuncu Yil University
Turkey
sevgi.aydin45@hotmail.com

Elif Selcan ÖZTAY
Department of Elementary Education
Van Yuzuncu Yil University
Turkey
selcan.kutucu@gmail.com

Ayşegül TARKIN-ÇELİKKIRAN
Department of Mathematics and Science Education
Van Yuzuncu Yil University
Turkey
aytarkin@gmail.com

Betül EKİZ-KIRAN
Department of Mathematics and Science Education
Van Yuzuncu Yil University
Turkey
betulekiz@gmail.com

ABSTRACT
In this study, 24 experienced in-service teachers' science process skills (SPSs) development and their use of SPSs in their lesson plan through a week-long professional development (PD) supported by the Scientific and Technological Research Council of Turkey (#117B302) were studied. SPSs are important part of scientists' work, scientific literacy, science education, and problem solving. In this research, SPSs were examined under two main categories, (i) basic SPSs and (ii) integrated SPSs. Basic SPSs are prerequisite for development of integrated ones that have also two sub-categories, namely, verification type and authentic experiment design. Through the PD provided by chemistry teacher educators, participant chemistry teachers received a training that balanced both theory and application of inquiry strategy. In the PD, teachers participated in all activities sand conducted all activities that are chemistry experiments based on inquiry. Moreover, during the activities they wrote hypothesis, designed experiments, controlled variables, collected and analyzed the data, and presented their conclusions to other groups. The data were collected through a with 36 multiple choice items. The test was administered as pre- and post-test. The statistical analysis of the data was performed with SPSS.23 package program. To compare and contrast the scores, paired sample t-test was run. Results revealed that there is a statistically significant difference in teachers' SPSs score in favor of post-test ($t=2.508$, $p<.05$). In the light of the results, it can be suggested that longitudinal PDs should be organized more frequently. Moreover, active participation of teachers into the activities should be provided.

INTRODUCTION

There is a growing need for people to learn how to reach and interpret scientific knowledge with changing and developing scientific and technological developments. Parallel with changing conditions in the world, both learning and teaching environments should be changed and modified in terms of 21st century learner skills such as science process skills, critical thinking, life skills etc. Within the scope of 21st century skills, to ensure learners acquire those skills, teachers should utilize instructional strategies including making brainstorming, solving a real life problem, identifying dependent/ independent variables, and designing an experiment (Finlayson, McLoughlin, Coyle, McCabe, Lovatt, & van Kampen, 2015; Köseoğlu & Bayır, 2012). The main aim should be enriching learners with critical thinking and inquiry skills through their education. At this point, science process skills (SPSs) have crucial role by giving a chance to students to produce scientific knowledge and utilize nature of science by experiencing scientific knowledge.

SPSs generally refer abilities that every individual can use in all stages of daily life in order to become a scientifically literate person, to understand and use scientific knowledge, and to improve the quality and adaptation of social life (Bozkurt & Olgun, 2005; Işık & Nakiboğlu, 2011; Karapınar, 2016). In order to train learners with , those skills and knowledge, inquiry-based approach, in which learners are active participants of knowledge acquisition and solve problems faced with everyday life, are necessary (Finlayson et al. 2015; Köseoğlu & Bayır, 2012). In order for teachers to implement effective science instruction including inquiry based approaches, they should improve their both knowledge and experience in terms of teaching and learning science via professional development programs (Cotabish, Dailey, Hughes, & Robinson, 2011).

The main purpose of the study to investigate the development of experienced chemistry teachers' SPSs and integration of SPSs into their activity design through professional development. This study aimed to address following research questions:

- Is there any effect of professional development program on experienced teachers' science process skills?
- How professional development program improve experienced teachers in terms of designing inquiry-based chemistry teaching activities?
- How experienced teachers' knowledge and opinions pertained to inquiry and inquiry-based learning change through professional development program?

LITERATURE REVIEW

SPSs and Its Categorizations

Although science process skills (SPSs) simply defined as skills that scientists use in their studies, they are utilized by everyone in order to be scientifically literate people (Harlen, 1999). There were various definitions of SPSs in the literature. For instance, Çepni, Ayas, Johnson and Turgut (1997) defined SPSs as special skills that simplify learning science, activate students, develop students' sense of responsibility in their own learning, increase the permanency of learning, as well as teach them the research methods. Gultepe (2016) defined them as "the tools that students use to investigate the world around them and to construct science concepts" (p.780). Those skills are also considered as the thinking skills that we use to process information, to think about solving problems, and formulate conclusions (Karamustafaoğlu, 2011; Tan & Temiz, 2003,). Moreover, SPSs generally refer abilities that every individual can use in all stages of daily life in order to become a scientifically literate person, to comprehend the nature of science, and to improve the quality of life (Aktamış & Ergin, 2007; Bozkurt & Olgun, 2005; Işık & Nakiboğlu, 2011; Karapınar, 2016; Saat, 2004). Although researchers discussed almost same SPSs in the literature, there are different categorizations for these skills as well as different definitions. In other words, there is no consensus on their categorizations. While some researchers categorized the SPSs in two groups as basic and integrated ones (American Association for the Advancement of Science [A.A.A.S.] 1998; Lancour, 2005, cited in Kanlı & Yağbasan, 2008), some of them grouped those under three levels as the basic processes, causal processes, and experimental processes (Çepni et al., 1997). In this current study, we adopted the first categorization that examines SPSs under two main categories, namely, basic SPSs and integrated SPSs.

Basic SPSs entail observation, classification, recording data, measurement and using numbers, time and spatial relationship, and communication. Those skills can be used in both scientific studies and daily life. On the other hand, integrated ones are more complex skills, including the use of two or more basic skills together. The latter category has two sub-categories, namely, verification type and authentic experiment design. Verification type includes skills used in the process of performing an experiment to confirm a truth. These skills are prediction, identifying variables, operational identification and interpreting data. Authentic experiment design refers the skills that individuals used while design an experiment and performing it. These skills are hypothesizing, designing experiments, changing and controlling variables, processing data and creating model, and decision making (Aslan, Ertaş-Kılıç, & Kılıç, 2016; Şen & Nakiboğlu, 2012).

Scientific Literacy, Inquiry, & Science Process Skills Development

Scientific literacy, has been the critical and ultimate educational outcome in many countries all around the world (National Research Council [NRC], 1996, Organisation for Economic Cooperation and Development [OECD], 2015). Although scholars have defined it in different ways, scientific literacy can be described as ''knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity" (NRC, p.22). In addition to science content knowledge about scientific concepts and principles, scientific literacy concept has other facets that are nature of science (NOS) understanding, how science and its products affect the society and individuals (OECD, 2007). In order to train learners with those skills and knowledge, inquiry-based approaches in which learners are active participants of knowledge acquisition and solve problems faced with everyday life are indispensable (Finlayson et al., 2015; Köseoğlu & Bayır, 2012). In addition to that, research has reported that inquiry-based approach helps learners develop positive attitude towards science (Chatterjee, Williamson, McCann, & Peck, 2009). Recently, science

education researchers revealed that socio-scientific contexts that have a potential to support scientific literacy development especially for social and political aspects of science and its applications (Sengul, 2019).
In the literature, inquiry has been used in different ways and with different meanings, for instance, inquiry as the way of doing science and inquiry as an instructional strategy (NRC, 1996). Inquiry approach implemented in science education is useful in developing SPSs (Germann, Aram, & Burke, 1996). Developing SPSs has pivotal roles in problem solving, and learning science (Carin & Bass, 1997; Gillies & Nichols 2014), and increasing children's curiosity (Settlage & Southerland, 2007). Regarding the importance of SPSs, Settlage and Southerland (2007) stated that "[t]eaching science with too much emphasis on the content would be like teaching language arts by providing students with a few nouns but no verbs and expecting them to construct sentences" (p. 32). Hence, science education practices should include activities, projects, and experiments through which learners have a chance to develop those skills.
In the literature, many studies have been focused on K-12 learners' SPSs development. However, not many studies worked on teachers' SPSs. Teachers' SPSs understanding and integrating those skills into their lessons are vital for supporting learners' SPSs development (Dudu & Vhurumuku, 2012). Research has shown that teachers' knowledge and understanding of SPSs is limited (Shahali, Halim, Treagust, Won, & Chandrasegaran, 2017).

SPSs Development for Teachers
Teachers play a crucial role in assisting students' acquisition of SPSs. A teacher who is not properly equipped with those skills may experience difficulties in transferring SPSs to his/her students (Feyzioğlu, 2009). Therefore, science teachers are expected to develop SPSs and be able to transfer SPSs to their students (İnce-Aka, Guven & Aydogdu, 2010; Kruea-In & Buaraphan, 2014; Miles, 2010; Özer & Özkan, 2012). Numerous studies have been conducted to examine views and sufficiency of teachers, preservice teachers and students about SPSs in literature. Many research studies revealed that science teachers' and preservice teachers' SPSs were insufficient (Aydoğdu, 2006; Chabalengula, Mumba & Mbewe, 2012; Emereole, 2009; Feyzioğlu, 2009; Karslı, Şahin & Ayas, 2009; Mbewe, Chabalengula & Mumba, 2010; Pekmez, 2001; Yıldırım, Atilla, Özmen & Sözbilir, 2013). Those studies reported the fact that especially research-based activities or laboratory work related interventions such as project-based (e.g., Abdulhanung, Supasorn & Samphao, 2011; Hernawati, Amin, Irawati, Indriwati, & Aziz, 2018; Özer & Özkan, 2012), problem-based (e.g., Saputro, Irwanto, Atun & Wilujeng, 2019), and inquiry-ased ones (e.g., Ateş, 2005; Budak-Bayır, 2008; Ergül et al., 2011; Irwanto, Saputro, Rohaeti & Prodjosantoso, 2019; Köksal & Berberoğlu, 2014; Kruea-In & Buaraphan, 2014; Nworgu & Otum, 2013; Şen & Sezen-Vekli, 2016) enhanced SPSs development. For instance, Şen and Sezen-Vekli (2016) conducted a study with 24 sophomore pre-service science teachers in General Biology Laboratory by using pretest and post-test quasi-experimental design. They found out the positive influences of inquiry-based teaching approach on pre-service science teachers' SPSs. Similarly, Irwanto et al. (2019) supported that inquiry-based laboratory instruction is an effective method to foster preservice teachers' SPSs. Saputro et al. (2019) conducted a quasi-experimental control group pretest-posttest design research with 48 preservice elementary teachers and revealed that the usage of problem solving instruction in the classroom promoted students' SPSs significantly. During the problem solving instruction lasting six weeks, preservice teachers required to identify the problem, devise a plan to solve the problem, carry out the plan and examine the problem solving. In another study, Hernawati et al. (2018) analyzed the effectiveness of Project-based activities on scientific process skill through a quasi-experimental research. Project based activities conducted under five steps: (1) student orientation on project issues, (2) organization of teaching and learning activities, (3) guidance for students to carry out project activities, (4) development and presentation of project results, and (5) analysis and evaluation project result. In this study, it was revealed that project based activities helped the students to reach better SPSs when compared the conventional laboratory work. In the study of Kruea-In and Buaraphan (2014), 36 secondary school science teachers were allowed to conduct experiments through a professional development workshop was designed based on social constructivist view. Assessment of SPSs of teachers by the Performance Test of Science Process Skills (PTSP) before and after the workshop indicated that the number of SPSs in which teachers showed high performance increased after attending the workshop.

Professional Development (PD)
Although different definitions of PD have been existed in the literature, we adopted Paechter's (1996) definition, that is "an activity in which the individual and the group interact to develop better models for practice which preserve the best of professional autonomy while promoting the sort of reflective culture that encourages constructive, cooperative change" (p.354). Reforms, changes, and technological developments makes PD be inseparable part of teachers' professional life, which is also related to results of changes in educational systems (Borko, 2004). In order to increase the effectiveness of reforms made and support teachers' development, PDs should have some specific characteristics, namely, focusing on a content, active participants who take active role in learning, coherence among PD- curriculum objectives and teachers' practice, long duration and recurring trainings, and collective participation (i.e., from same school, participation from the same field or grade). To

conclude, PDs are important both for updating teachers' knowledge and practice, and success of educational reforms.

METHODOLOGY

Type of the Study

In the current study mixed method design was used (Creswell & Plano Clark, 2011). Both quantitative and qualitative data were collected throughout PD to provide detailed results for 24 experienced chemistry teachers' SPSs development and their integration of SPSs into their plans.

Participants

Participants of the study were 24 (12 female and 12 male) in-service experienced chemistry teachers. They have chemistry teaching experience of at least 10 years. They were teaching chemistry at high schools in different cities of Turkey.

PD Description

The PD project was supported by the Scientific and Technological Research Council of Turkey (#117B302). During the week-long PD, in-service teachers involved in 13 different sessions led by chemistry educators. Sessions lasted 2 to 4 hours. While some of the sessions provided in-service teachers theoretical knowledge about inquiry-based teaching, others led them practice inquiry activities. Aims of the sessions and activities conducted in each session were provided in Table 1.

Table 1. Aims of the Activities Conducted in each session during the PD

Session/Activity	Aim of the activity
How do we change a traditional laboratory activity into an inquiry-based laboratory activity?	to raise awareness of chemistry teachers about inquiry-based teaching practices and to provide experience in converting a cookbook activity to an inquiry-based activity
Which one is burning? Wick or Candle?	to arouse curiosity towards science with inquiry-based chemistry teaching, to develop SPSs, to gain motivation and confidence in participating in a scientific discourse, to develop deep understanding of NOS
Problem Based Learning Applications in Chemistry	to enable chemistry teachers acquire knowledge and skills to help them apply Problem Based Learning in their lessons
Science Technology Engineering Mathematics (STEM) and Engineering Design	to give information about the development of STEM education and how it can be used in science courses
Design-based STEM	to develop inquiry skills and engineering design skills of the chemistry teachers
How do we determine the products of chemical reactions?	to enable chemistry teachers to experience an instructional process prepared by using argumentation based inquiry for teaching chemical reactions
Generating Electricity from Chemical Energy	to convert chemical energy into electrical energy with the cheapest and highest efficiency by using different variables. (In this way, participants will be able to work in groups, form a hypothesis by using their pre-knowledge of the problem, design their own hypothesis by using the tools and equipment available, and predict the results of the observations)
Applications of Concept Cartoon Activities Based on Argumentation in Organic Chemistry	to understand the importance of argumentation-based instruction in organic chemistry teaching, to understand the important points to be considered while developing activities according to Toulmin's argumentation model, to comprehend the important points to be considered in the preparation of concept cartoons

Journey to Discovery of Atmospheric Pressure	to enable teachers to examine the competing theories in the discovery of atmospheric pressure and the scientific research and reasoning process of a scientist (Torricelli)
Comparison of the Effectiveness of Antacid Tablets Produced by Different Brands	to design an experiment to compare the effectiveness of the antacid tablets produced by different brands, to determine the variables that will be worked to use inquiry approach on acid-base with guided inquiry
Computer Assisted Inquiry	to participate in research-inquiry processes by using technology-based models in a learning environment with technological tools and equipment.
Using Analogy Method to Question the Properties of Chemical Equilibrium	to embody the concept of chemical equilibrium where the forward and reverse reaction rates are equal by using simple materials (beans, paper clips, etc.) to comprehend that chemical equilibrium is not static but dynamic
Augmented Reality Applications Based on Guided Inquiry in Chemistry Teaching	to show the practical applications of chemistry activities based on guided inquiry with the applications of augmented reality

Data Sources

Science process skills test, preparation of inquiry-based chemistry teaching activity, and chemistry teachers' opinions about inquiry-based teaching were used as data sources to answer the research questions asked. Detailed information about the data sources is provided below:

a) Science Process Skills Test

In order to measure the participants' SPSs, the Science Process Skill Test that was developed by Burns, Okey and Wise (1985) and translated into Turkish by Geban, Askar and Özkan, (1992) was administered. The reliability of the Turkish version of the test was $\alpha = 0.82$. The test consists of 36 multiple-choice questions. In this test, identifying variables (12 questions), defining operationally (6 questions), stating hypothesis (9 questions), graph and interpreting data (6 questions) and designing investigations (3 questions) skills were tried to be measured.

b) Preparation of Inquiry-Based Chemistry Teaching Activity

In this PD, it was aimed to help teachers gain experience in teaching with inquiry method in their professional lives. For this purpose, the teachers were asked to prepare an inquiry-based chemistry teaching activity at the beginning and at the end of the PD in order to determine the contribution of the PD to the teachers' level of developing inquiry-based chemistry teaching activities. Teachers were free to choose the high school chemistry topic that will be the focus of the activity preparation.

c) Chemistry Teachers' Opinions about Inquiry-Based Teaching

Teachers were asked to respond some questions about inquiry-based teaching at the beginning and at the end of the PD. Examples to the questions were:

1. What is inquiry method?
2. What is the purpose of the teaching with inquiry method?
3. In your opinion, what are the advantages (strengths) and disadvantages (weaknesses) of inquiry?
4. What do you think about the applicability of the inquiry method?

Data Analysis

First, teachers' pre and post-tests were coded as true (1 point) and wrong (0 point). Then, the data were entered to SPSS package program. The comparisons of pre-test and post-test scores of Science Process Skill Test were analyzed by running t-test.

Second, inquiry activities prepared by teachers were evaluated by a rubric scale developed by Fay, Grove, Towns and Bretz (2007) (Table 2).

Table 2. Rubric for Evaluating Inquiry Levels of the Activities Developed by Teachers

Level	Problem	Method	Results
Verification (0)	Provided	Provided	Provided
Structured Inquiry (1)	Provided	Provided	Not provided
Guided Inquiry (2)	Provided	Not provided	Not provided
Open Inquiry (3)	Not provided	Not provided	Not provided

Through this scale, the inquiry levels of the activities prepared by teachers were coded as "Not provided to the student" or "Provided to the student" for problem, method and results criteria. In addition, the SPSs that are aimed to be developed through activities planned by teachers were evaluated using Table 3.

Table 3. Science Process Skills Used in the Activities Developed by Teachers

Science Process Skills	***Skills focused on in the pre-developed activity***	***Skills focused on in the post-developed activity***
Observation		
Classification		
Inference		
Prediction		
Identifying variables		
Design an experiment		
Measuring		
Data collection		
Controlling variables		
Interpreting data and formulating models		
Decision making		
Presentation		

Finally, teachers' opinions were analyzed qualitatively by the research team. Teachers' responses were analyzed by content analysis.

RESULTS

Results for the Analysis of SPSs Test (1st research question)

Data were analyzed by paired sample t-test in SPSS.23 program. Results of the study revealed that inquiry-based teaching activities provided a significant increase in the participants 'science process skills test scores ($t = 2.508$, $p < .05$). Results obtained from paired sample t-test analysis are presented in Table 4.

Table 4. Results of Paired Sample t-test Analysis of the Total Scores Obtained from Pre and Post Implementation of Science Process Skills Test

		X	**N**	**S**	**SD**	**t**	**p**
Science Process Skills Test	Pre-test	26.13	24	3.675			
	Post-test	28.00	24	4.243	23	-2.508	.020

Science process skills test includes 5 sub-dimensions (i.e., identifying variables, operationally defining, stating hypothesis, interpreting data, and designing investigations). Table 5 shows the teachers' average scores of pre- and post-tests for each sub-dimension.

Table 5. Pre- and Post-Test Results for the Sub-dimensions of Science Process Skills Test

Identifying variables	Pre-test	6.3750	24	1.95187
	Post-test	7.6667	24	2.53097
Operationally defining	Pre-test	4.6250	24	.96965
	Post-test	5.0833	24	1.05981
Stating hypothesis	Pre-test	7.0417	24	1.36666
	Post-test	7.4167	24	1.50121
Interpreting data	Pre-test	5.3333	24	.76139
	Post-test	5.2500	24	.79400
Designing investigations	Pre-test	2.7083	24	.55003
	Post-test	2.5833	24	.65386

The scores obtained from pre- and post-tests for each sub-dimension were analyzed by paired sample t-test. It was revealed that there was a significant difference between the scores. When Table 6 was examined, it can be seen that there is a meaningful significant difference between teacher scores for the first sub-dimension, identifying variables, in favor of post-test ($t = -2.089$, $p < .05$).

Table 6. Results of Paired Sample T-Test Analysis of Teachers' Pre- and Post-Test Scores of the Sub-Dimensions of Science Process Skills Test

	X	S	t	SD	p
Identifying variables	-1.29167	3.02855	-2.089	23	.048
Operationally defining	-.45833	1.21509	-1.848	23	.078
Formulating hypothesis	-.37500	1.17260	-1.567	23	.131
Interpreting data	.08333	.82970	.492	23	.627
Designing investigations	.12500	.61237	1.000	23	.328

Results for the Analysis of Activities in Terms of Science Process Skills (2nd research question)

One of the purposes of the current PD program was providing inquiry-teaching experience which teachers can reflect in their professional lives. For this aim, at the beginning and at the end of the PD program, they were expected to prepare an inquiry-based chemistry teaching activity on any subject they wanted in order to determine the contribution of the program in terms of designing inquiry-based chemistry teaching activities. As a result of the analysis, science process skills emphasized by them are presented in Table 7.

Table 7. Science Process Skills Provided in the Activities Developed by Teachers

			Number of participants emphasized in pre-test	Number of Participants emphasized in post-test
Basic Science Process Skills	Observing		11	11
	Measuring		4	3
	Classifying		4	1
	Recording data		0	8
	Using space-time relationship		0	1
	Communicating		3	15
Integrated science process skills	Verification experiments	Predicting	2	3
		Identifying variables	0	1
		Defining operationally	0	0
		Drawing conclusions	11	12
	Design and Application of an Authentic Experiments	Formulating hypotheses	1	0
		Setting up experiments	0	9
		Controlling variables	0	0
		Interpreting data and formulating models	0	0
		Decision making	0	2

SPSs were examined in two main categories, namely, basic and integrated science process skills. In addition, integrated science process skills were also examined in two sub-categories, namely verification experiments and design and application of an authentic experiments (Nakiboğlu, 2015). Results were presented with graphs for Basic and Integrated Science Process Skills (Figure 1).

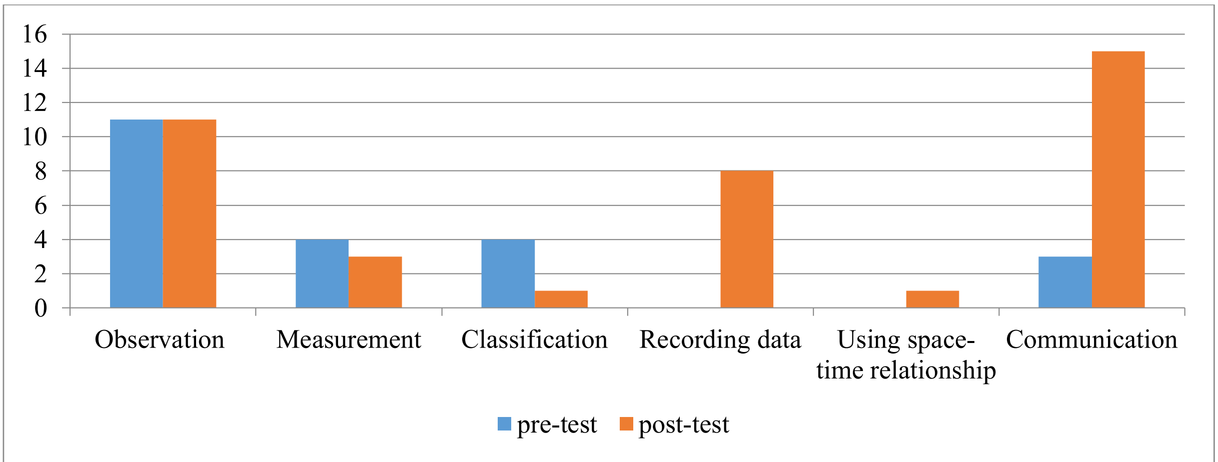

Figure 1. Basic SPSs emphasized in pre- and post-activity preparation

In the initial activities prepared by the participants, it was observed that they frequently integrated observation skill, which is one of the basic science process skills (n = 11) (Figure 1). In addition, measurement, classification and communication were included in the initially designed activities. Activities designed after the training included recording data and using space-time relationship SPSs, which were not included in the initially designed activities. In addition, there was a clear increase in the use of communication skills, which included sharing of the results with other groups and creating tables and graphs for sharing results, from the first to the last application. Measurement and classification skills were less involved in the post-activity preparation than were done in the first application.

Regarding the integrated SPSs, first, analysis of verification experiments, one of the sub-categories of integrated SPSs, was provided in Figure 2.

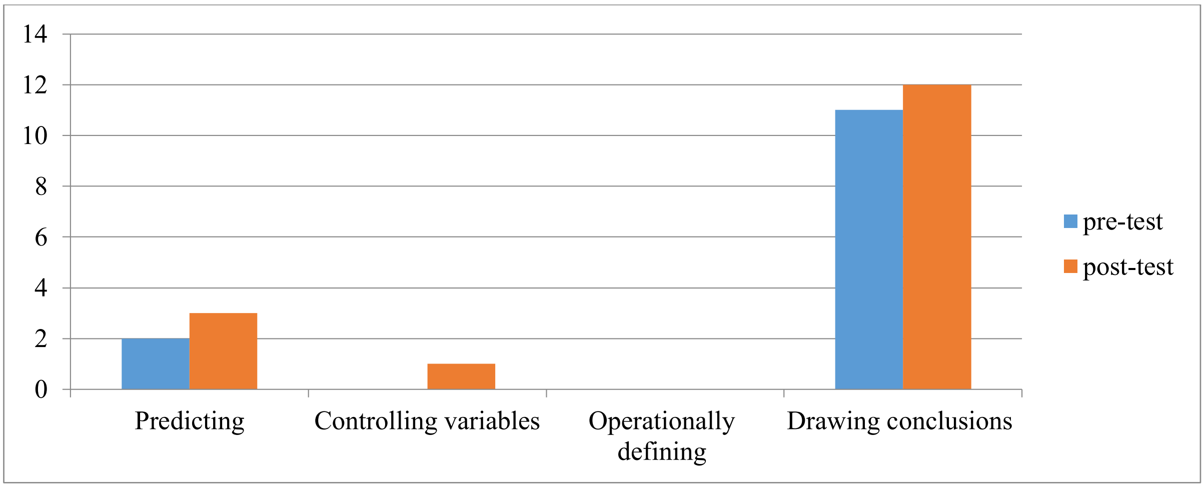

Figure 2. The level of verification experiments involved in pre- and post- designed activities

Before the PD, predicting and drawing conclusions skills were involved in the activities designed by participants. After the training, while the number of the participants integrating those two skills into the activities increased, identifying variables skill was also involved in the activities. Operationally defining skill was involved in neither the pre- nor post-application (Figure 2).

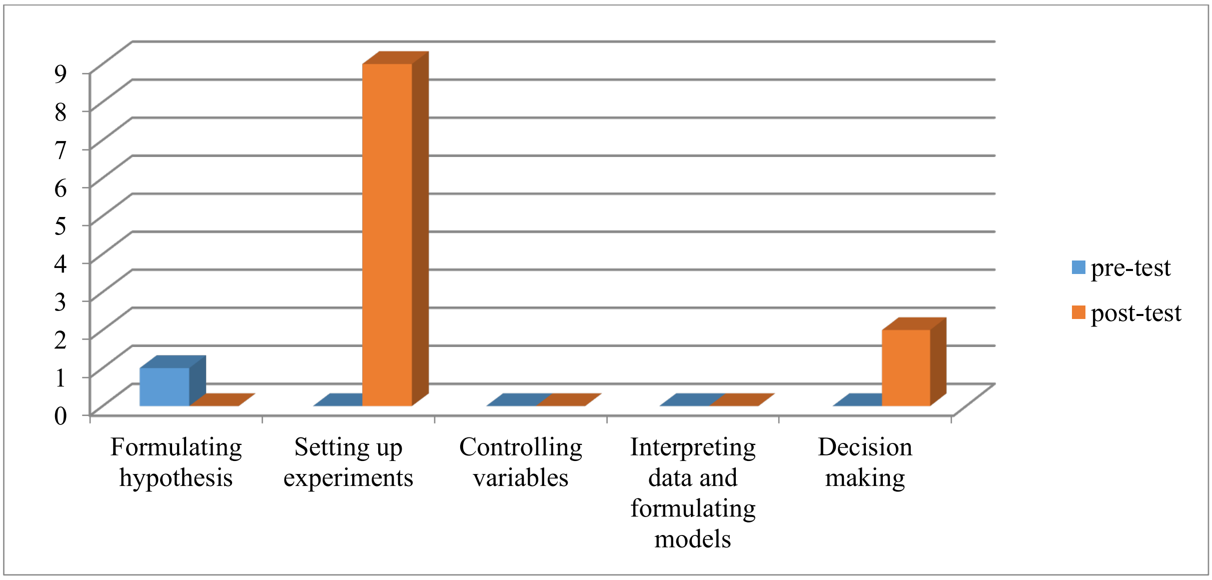

Figure 3. The level of design and application of an authentic experiments involved in the pre- and post- activities

The only science process skill involved in the initially designed activities was formulating hypothesis, which was one of the components of design and application of an authentic experiments (Figure 3). Activities designed at the end of the training involved setting up experiments (n=9) and decision making (n=2). Controlling variables and interpreting data and formulating models were not involved in the pre-or post-designed activities.

The PD training, which aimed to train participants how to teach inquiry and use SPSs in activities, a comparative analysis of the data collected in the pre- and post- activity design was conducted (Figure 4). This analysis provided an overview of basic and integrated SPSs.

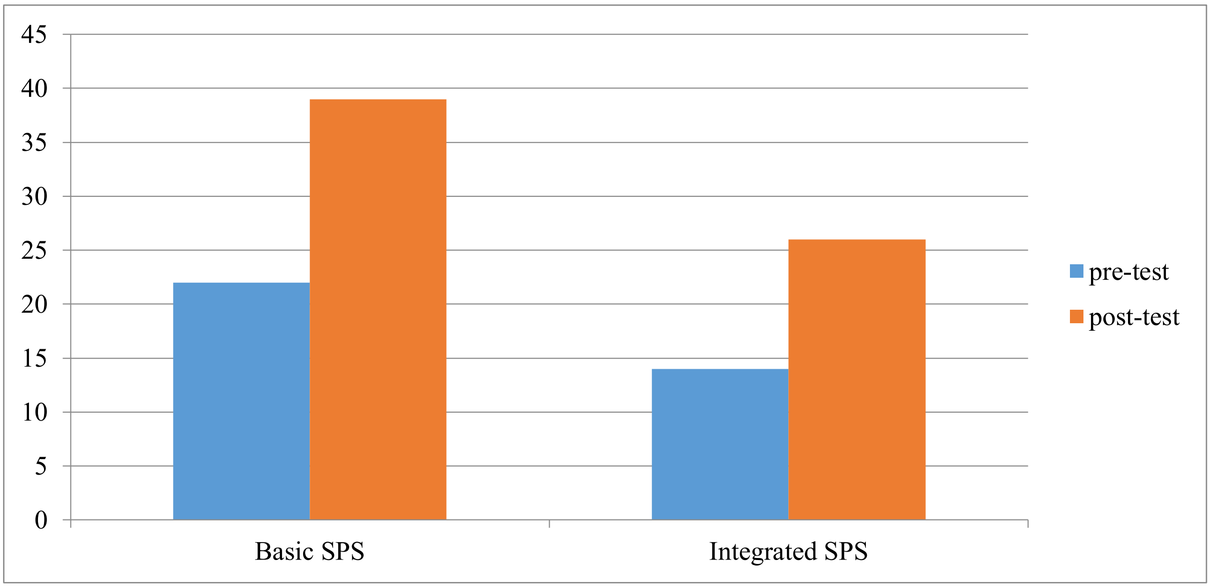

Figure 4. Degrees of basic and integrated SPSs in the pre- and post- activity design

Regarding the inclusion of basic and integrated SPSs in the activities developed by teachers, there was an increase in favor of the activities developed after the training. But still there was no improvement in integrating some SPSs (e.g., operationally defining, controlling variables, and interpreting data and formulating models) (Figure 4). It was seen that at the end of the training, participants focused more on the practice of SPSs while developing activities. Especially design and application of an authentic experiments sub-category was the backbone of the implementation of this approach. Nine participants asked students to design authentic experiments instead of giving students the procedure of the experiments.

Results for the analysis of teachers' opinions pertained to inquiry and inquiry-based learning (3rd research question)

Teachers' knowledge and opinions about inquiry and inquiry-based learning were obtained both at the beginning and at the end of the training with the help of open-ended questions. The results obtained from the analysis of the data were given below as pre-test and post-test results, respectively.

Pre-test Results

The majority of participants defined inquiry as the process of learning and acquiring knowledge by questioning (n = 5), doing research (n = 8) and asking questions (n = 8). For example, teacher 1(T1) stated inquiry as ''a method of learning by questioning, using scientific knowledge and doing research." T2 stated that "it is a process of accessing knowledge by asking questions about a problem, event or situation." Other expressions used to define inquiry learning were learning by doing (n=2) and doing research on why and how (n = 3). For example, T3 defined inquiry method that ''enables students to reach information by thinking and experimenting." T4 stated that "it is not to give information to the students but enable them to reach the knowledge by searching for why and how."

In addition, inquiry method was evaluated as a method in which the student was active (n = 2) and away from memorization (n = 2). However, it was not clearly stated what was meant to be active and far from memorization. Analyzing data (n = 3) was the only higher level thinking skill stated as a component of the inquiry research. Furthermore, inquiry was defined in different ways by the teachers. These definitions included scientific method (e.g., T5's definition), research method (e.g., T6's definition), process (e.g., T2's definition) and learning method (e.g., T7's definition). When all the teachers' opinions about inquiry method were examined, it as seen that the definitions were general and contain many expressions that are not unique to the inquiry method. In particular, teachers defined inquiry simply as questioning, doing research, and asking questions. However, they do not give details about how to do them.

Post-test Results

The most striking part of the post-test results was that the majority of the teachers used expressions that support student-centered instruction (n = 15) while defining inquiry teaching. In the inquiry method, the student was defined as the person who was involved in the learning process, asks questions, investigates and thinks. For example, T8 explained student's involvement in the learning process as “a way of learning in which students respond to questions by analyzing data that they collect”, while T9 explained it as “a student-centered learning process in which students are responsible from their own learning.” In addition, as a student, being mentally active (n = 2) was expressed as one of the characteristics of the inquiry method. For example, T10 stated "inquiry is a learning method in which knowledge is structured through mental processes such as estimation, observation, analysis and evaluation."

Another remarkable point was that almost all of the teachers emphasized at least one of the SPSs in defining the inquiry method after the PD. Identifying a problem or a research question (n=10) was the mostly stated SPS by participants. T11 explained it as “the process of collecting data with the help of a research question to attribute meaning to the data.” Formulating hypothesis (n = 3) was mentioned by T12 as “the sum of the processes of collecting and analyzing evidence and data in order to solve a scientific question about the everyday life.” Data collection (n = 5), observation (n = 4), analysis (n = 4), inference (n = 2), evaluation (n = 3) were among the SPSs used in definitions. For instance, T13 claimed that “inquiry is an innovative learning method that provides students the opportunity to do research, scientific thinking, inference, evaluation, and interpretation.” In addition, inquiry was often defined as a teaching-learning method or process by the participants. When the post-test results were examined, it as seen that participants defined inquiry as a learner-centered method that includes teaching and practice of SPSs.

DISCUSSION

Regarding the context of 21st century learning, possessing, and experiencing SPSs are considered as main purpose of learning science (Irwanto, Rohaeti & Prodjosantoso, 2018; Karsli & Şahin, 2009). First, this study is a small part of a large project that includes week-long PD offered to 24 in-service chemistry teachers. In the light of the literature that has reported the significant contribution of inquiry—based, project- and problem-based training on SPSs development, the researchers designed a PD with activities based on those strategies with a hope to give a chance to teacher to experience inquiry based activities. Regarding this point, Desimone (2009) has stated that one of the most important features of PD is active participation of teachers rather than passive listeners of presentations made by experts. In our PD context, we paid specific attention to active participation of teachers into more than ten sessions including activities that help teachers develop SPSs. To be clear, to support the teachers’ SPSs development, the teacher educators let them hypothesize, control variables, collect data, analyze data, and interpret them during each session. As a result of the study, it can be concluded that the chemistry teachers have acquired and improved both basic and integrated SPSs to some extent through PD program. Although they did not know much about SPS at the beginning, at the end of the PD, test results showed increase in their SPSs. Moreover, participants could integrate more SPSs into the activities that they develop at the end of the PD. After PD program, especially at design and application of an authentic experiments sub-category, there was a remarkable improvement. In this change, sessions including inquiry-based activities that required participants to hypothesize, design an experiment, collect data, and analyze data may help them learn how to achieve those (e.g., how to write an hypothesis). Corresponding to Crawford et al., (2014) teachers do not have SPSs and know well about how to integrate SPSs. However, if they take support, they are able to achieve those. Teachers also changed their perspective from giving learners the procedure of the experiments to ask learners to design authentic experiments. At the beginning, teachers prepared an activity that included all details such as how to collect data, aim of the activity etc. However, in the post activity preparation, they preferred to give less details and asked more from learners. This revealed that PD program including active participation of teachers into inquiry based activities makes teachers obtain how to integrate those SPSs (e.g., predicting, controlling variables, drawing conclusions, recording data, controlling variable) into the activity. This result is also supports Ketpichainarong, Panijpan, and Ruenwongsa’s (2010) point that training helps teachers to change their classroom view from traditional to constructivist one. Similar to previous studies (Ergül et al., 2011; Irwanto, et al., 2019; Köksal & Berberoğlu, 2014; Şen & Sezen-Vekli, 2016) the findings of this study have shown that hands-on activities incorporating inquiry based teaching to chemistry instruction improve SPSs. It is recommended that in order for the teachers to acquire SPSs, they should be directly participated in the inquiry process. However, as stated earlier, we observed low mean scores for some sub-dimensions of the test (e.g., identifying variables, stating hypothesis), which shows that in the future studies, teacher educators should pay specific attention to those sub-dimensions and provide more opportunities for teachers to identify variables and write hypothesis during PD.

Second, teachers have a vital role in learners’ development of SPSs. Teachers with limited SPSs may had difficulty in transferring those skills to learners (Feyzioğlu, 2009). Hence, teachers’ knowledge and experience in terms of

SPSs should be improved (Blanchard et al., 2010; Kruea-In & Buaraphan, 2014; Özer & Özkan, 2012). However, studies on SPSs development in the related literature have been focused more on pre-service teachers' (Irwanto et al., 2019; Saputro et al., 2019; Şen & Sezen-Vekli, 2016) or K-12 learners' SPSs development (Ergül et al., 2011; Kanlı & Yağbasan, 2008). Hence, more studies should be focused on in-service and experienced teachers' SPSs development and how they incorporate SPSs into their laboratory work. By doing so, as in other countries (e.g., Singapore, Australia, United States of America) (Crawford et al., 2014), through the successful use of inquiry-based strategy in Turkey we will reach the ultimate goal of teacher education that is training more qualified learners who are able to think critically, do research, and have SPSs. In other words, we will reach the goal of educating scientifically literature citizens.

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