The effect of an instructional intervention on enhancement pre-service science teachers' science processes skills

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Abstract

The aim of this study is to investigate the effects of an instructional intervention on enhancement the pre-service science teachers' (PSTs) science process skills (SPSs) and to identify problems in using SPSs through Laboratory Applications in Science Education-I course (LASE-I). One group pretest-posttest pre-experimental design was employed. An instructional intervention was performed in order to integrate the learning of science processes into the flow of the traditional cook-book LASE-I course by embedding inquiry-oriented activities into the redesigned laboratory applications course for enhancing the PSTs' awareness and understandings of science processes. The intervention was supported by means of scaffolding at strategic points. The test of SPSs consisting of 36 multiple-choice questions and including five sub-sets process skills objectives was administered to define integrated process skills of the participants. The worksheets and/or experiment reports of the PSTs were used as qualitative data resources, and their performances related the skills of designing experiment, graphing, and tabulating data were analyzed using the multiple format instruments including analytic criteria scale of designing experiment, checklist of line graph, and tabulating data skills test. A question form was also utilized at the end of the semester in order to find out the PSTs' opinions about the effect of the course. At the end of the study, while it had some limitations, it is possible to suggest that the instructional intervention embedded inquiry-oriented lab activities had a positive effect on enhancement of the PSTs integrated SPSs.

Keywords: Instructional intervention, laboratory practical activities, pre-service science teacher, science process skills

Introduction

Developing essential knowledge and skills, and understanding of science is a fundamental aim of science education. To this end, reform efforts have been expanded worldwide to increase the quality of education. The wave of science education reform has affected Turkey as many countries as well. The Turkish Ministry of National Education (MoNE) has developed new science curriculum for middle schools as a part of a larger scale educational reform (MoNE, 2005). Then, the curriculum also has been revised in 2013. Scientific inquiry has an important focus in science education (NRC, 2000, 2012). New demands based on the revised science curriculum require science teachers should have adequate science content knowledge and scientific process skills to support students in acquiring knowledge and skills of scientific inquiry (MoNE, 2013). As known, teachers play a key role in making educational reforms successful and the achievement of curriculum depends on how well teachers internalize its each unit as a whole. Despite curricular emphases, many teachers do not have the understanding and skills to use inquiry thoughtfully and appropriately in their classrooms (NRC, 2000; Narayan and Lamp, 2010; Capps and Crawford, 2013; Donnellya, McGarr, and O'Reilly, 2014; Gillies and Nichols, 2015). In this sense, it is crucial that teachers and PSTs must become aware of the targets of the new science curriculum because they have a responsibility in the vision of reform. Therefore, PSTs need to participate in practical works since their first-hand practicing experiences in learning science is essential to become fluent to develop their own students' learning in the future.

Developing scientific process skills (SPSs) is one of the major goals of science education because of its central role in learning with understanding (Harlen, 1999). When inquiry approaches are put into practice in schools, it is expected to support the development of students' research skills and experiences as scientists do while doing research (Katsampoxaki-Hodgetts, Fouskaki, Siakavara, Moschochoritou, and Chaniotakis, 2015). Inquiry includes the combination of processes skills with content knowledge of science, scientific reasoning and critical thinking (Lederman, Lederman, and Antink, 2013). In the light of the literature, Arnold, Kremer, and Mayer (2014) stated that students should systematically acquire the abilities necessary to perform scientific inquiry and obtain an understanding about scientific inquiry as well as content knowledge. SPSs can be used as tools in science education to gain both conceptual and procedural knowledge and understanding of science, and they are needed to be scientifically literate (Keil, Haney, and Zoffel, 2009). Science content and SPSs are both essential elements of science education, and the learning of one aids the learning of the other (Rillero, 1998). Students [learners] must be able to master certain SPSs, including formulating questions, planning investigations, using tools and techniques of data collecting, and making evidence-based conclusions (NRC, 1996) to do inquiry.

Student-centred approach helps students to gain the acquisition of both science content knowledge and process skills (Bunterm et al., 2014). Balanay and Roa (2013) evaluated the high school students' performances such as setting up the equipment, following procedures, data collection, safety, and clean up procedure in conducting science laboratory experiment. They explored that the student-centred approach incorporated inquiry based science teaching had significantly improved the students' SPSs. Similarly, Baseya and Francis (2011) mentioned that changing lab style to more student-centred approach could help students develop SPSs and understand the nature of science. Ketpichainarong, Panijpan, and Ruenwongsa (2010) explored the effectiveness of an inquiry-based laboratory designing activities which ranged from a guided to a more open inquiry for undergraduate biotechnology students. They concluded that the students gained acquisitions of skills such as asking good questions, predicting, problem solving, drawing conclusion, and communication along with content knowledge. However, Minner, Levy, and Century (2010) asserted that the evidence on the positive effects of inquiry-based education was not certain although there was a clear and positive trend favouring inquiry-based instructional practices, and also the relationship between the level of inquiry and the outcome of student achievement was modest. Similarly, Jiang and McComas (2012), presenting evidence based on PISA 2006 US data analysis, revealed that there is an unexpected negative correlation between the use of student investigations and student science achievement (as cited Jiang and McComas, 2015). Based on the literature, Yılmaz-Tüzün and Özgelen (2012) suggested that students' failure in science could be ascribed to not using SPSs effectively by taking the relationship between students' science achievement and use of SPSs into account. In another study, Arnold, Kremer, and Mayer (2014) studied on what kind of support students needed in inquiry tasks, and found that students needed support on procedural knowledge and understanding. Particularly focusing on designing experiment, they concluded that students need scaffolding in basic aspects of designing experiment such as determining dependent and independent variables, test times, and repetitions.

Scientific inquiry consists of different levels of abilities. Based on the literature, Yeh, Jen, and Hsu (2012) reported that research studies recommend teachers to continuously develop their own inquiry skills and instructional knowledge because their experiences have an important impact on how students develop inquiry abilities. Considering the importance of teacher education, Kim and Chin (2011) aimed to understand the challenges and difficulties in practicing inquiry work for pre-service science teachers (PSTs), and to develop their views and willingness for practicing inquiry activities through redesigning and practicing textbook activities. Researchers expressed that the PSTs gradually overcame their resistance and reluctance toward inquiry and practical work, and developed willingness and motivation to practice in everyday science classrooms. Accordingly, PSTs firstly should develop necessary SPSs, which are components of inquiry skills, in order to become effective guides for their students in the future. In the literature, most studies have not directly addressed SPSs of PSTs. However, studies related to PSTs' experiences with inquiry and nature of science (NOS) provide some information about their proficiency in using SPSs that are indirectly related to inquiry practices in their courses. The literature points out that PSTs have problems with using SPSs (e.g., Abd-El-Khalick and Akerson, 2004; Plevyak, 2007; Yılmaz-Tüzün and Özgelen, 2012) and they have generally low level of SPSs (Leonard, 2009; Yıldırım, Atila, Özmen, and Sözbilir, 2013), because they did not have experiences of inquiry-based science instruction in their backgrounds (Kenny, 2010; Leonard, Boakes, and Moore, 2009). In this regard, primarily, enhancing SPSs of PSTs before their professional career is important for their long-term professional success as PSTs play a critical role in preparing scientifically literate students.

In this study, the aim was to investigate the possible effects of an instructional intervention which was performed in order to integrate the learning of science processes into the flow of the course titled *Laboratory Applications in Science Education-I* (LASE-I) on enhancing the SPSs of PSTs, and to identify problems in using SPSs. The activities were redesigned by purposively putting an emphasis on some of the aspects of science processes in order to increase the PSTs' awareness and understanding of science process during the new redesigned laboratory applications course (R-LASE-I) term. The opinions of PSTs about the course progress were also investigated. To this end, the research questions were: (1) Did the SPSs levels of PSTs enhance significantly at the end of the instructional intervention? (2) Was there any correlation between the scores of the SPSs test and performance-based scores of the PSTs? (3) What were the problems of the PSTs in using SPSs? and (4) What were the opinions of the PSTs about the effect of the R-LASE-I course process on enhancing SPSs?

Methodology

Participants

This study was conducted with 38 PSTs who took the LASE-I course in the Department of Mathematics and Science Teaching at the Faculty of Education at a state university in Turkey. The participants were educated to become science teachers for 5-8 grades in elementary schools. With respect to background of the participants of laboratory and science teaching courses, they took the courses of the general physic lab I-II (2 term), the general chemistry lab I-II (2 term), and the general biology lab I-II (2 term). They have not yet enrolled to the science teaching methods course before the LASE-I course.

Research Design

In this study, one group pretest-posttest preexperimental design (Ary, Jacobs, and Sorensen, 2010) was employed. At the beginning of the study, the Test of Scientific Process Skills (TSPS) was administered as pretest to measure SPSs of the participants. Next, an instructional intervention was performed by embedding inquiry-oriented activities into the LASE-I course. The instructional intervention is explained in detail in the procedure section. At the end of the semester, the TSPS was employed as posttest to measure the SPSs of the participants enrolled R-LASE-I course. Differences were then evaluated by comparing the pretest and posttest scores. The study lasted for approximately 12 weeks during one academic semester. Both quantitative and qualitative data collection tools were used to collect data in order to triangulate multiple data sources to enhance the validity of the study (Fraenkel and Wallen, 2009). Data collection was spanned the whole one semester in which PSTs were enrolled in the laboratory applications in science education-I course.

Data Collection Tools

The tools to collect data included The Test of Scientific Process Skills (TSPS); Analytic Criteria Scale of Designing Experiment, Checklist of Line Graph, and Tabulating Data Skills Test (TDST); the worksheets and/or experiment reports of the PSTs; and a question form.

The Test of Scientific Process Skills (TSPS) which was developed by Burns, Okey, and Wise (1985) and adapted into Turkish by Geban, Aşkar, and Özkan (1992) was administered to define integrated process skills of the participants. The TSPS instrument consisted of 36 multiple-choice questions that tested the students' ability to identify the integrated SPSs. The test includes five sub-sets process skill objectives (identifying variables, identifying and stating the hypothesis, operationally defining, designing investigations and graphing and interpreting data). The Cronbach's alpha reliability coefficient of the test was found 0.716 for the participants. The TSPS was administered to the participants both at the beginning and the end of the semester.

Analytic Criteria Scale of Designing Experiment, Tabulating Data Skills Test (TDST), and Checklist of Line Graph developed by Temiz (2007) were utilized as scoring tools in order to quantitatively analyze the performance of the participants by means of worksheets and experiment reports. I selected these instruments because of including explicitly performance criteria. I used the analytic criteria scale of designing experiment to assess the PSTs' skills to plan, and conducted a simple experiment for testing their hypothesis. This scoring tool consists of 4 subcategories (such manipulated variable, responding variable, controlled variables, and testing hypotheses), and maximum 7 point could be received. I employed the tabulating data skills test (TDST) and the checklist of line graph in order to assess the skills of recording data by constructing data table, graphical representation, and graph interpretation. The TDST involves 6 subcategories (such as table title, table structure, name of variables, using appropriate units of variables (if there is), recording data, and organisation), and maximum 15 point could be taken. The checklist of line graph also encloses 6 subcategories (such as titles, scaling and naming the axes properly, drawing a proper graph using data and organisation), and the maximum point was 20. PSTs' written and observed performances were coded such as *3*, *2*, *1*, or *0* according to the level of fulfilment of the expected responses.

The worksheets and/or experiment reports of the PSTs were used as qualitative data resources and to collect information on problems on the PSTs' use of SPSs. The worksheets and/or experiment reports are important data tools reflecting the participants' performances in using SPSs (Harlen, 1999). Therefore, they were collected throughout the semester to enable tracking the PSTs' performances of using their SPSs. At the beginning of the study, the worksheets with scaffolding were given to draw attention to some elements such as variable-based scientific practices. As the study continued, -although the themes of the worksheets could be different according to their openness degree of the practical lab activity- in general, the parts of the worksheets included a research question or a scenario to capture students' attentions, the hypothesis, let's practice activity, let's record data, let's draw a conclusion, and what did I learn from this activity.

A question form which was consisted of 3 parts was administered at the end of the semester in order to find out the PSTs' opinions about the effect of the course. The first part of the question form developed by the researcher consists of 19 questions including 12 positive and 7 negative items. For example, as positive items; *the course session was effective on enhancing my own scientific process skills*, and *I* *realized my insufficient aspects of using my own scientific process skills through this lab course; and* as negative items; *I'm not sure I have developed my scientific process skills* items were given. This part was 3-point Likert type categorized as *yes*, *somewhat*, and *no*. The second part of the question form was adapted from the survey questions from Hoefnagels and Rippel's study (2003). Accordingly, the questions were first translated into Turkish by the researcher, and then an educational expert in both languages checked the appropriateness of the language of the questions. In addition to the original questions, one question was added to the survey by the researcher in order to understand the importance of the effective observation. The questions had three options: *I understood this subject very well before this course session*, *I now understand this subject much better*, and *I still don't understand this subject very well*. The third part of the question form included three open-ended questions: (1) What do you think about the effect of the R-LASE-I course applied during one academic semester? (2) What are your recommendations about the LASE-I course for future? (3) Did you have difficulties because of performing the instructional intervention within the LASE-I course?

Procedure

Description of the laboratory applications in science education-I (LASE-I) course

The LASE-I is a compulsory course (4 hours per week, 2h lecture and 2h lab implementation), and it covers the importance and objective of laboratory in science education, scientific method and SPSs, test worksheets and test report, measurement and error, worksheets and experiment reports, evaluation and assessment in laboratory.

The LASE-I course is an instructional laboratory course. In this study, it was aimed to make connections between learning to do science and teaching science through various laboratory practical works in the LASE-I course. To this end, an instructional intervention was performed in order to integrate the learning of science process into the flow of the traditional cook-book LASE-I course by embedding inquiry-oriented activities into the R-LASE-I course. Redesigned laboratory activities in different variations from closed-ended to open-ended were used to enhance the participants' SPSs through individual homeworks and small group assignments in- and off-class. The intervention was supported by means of scaffolding at strategic points such as how a hypothesis is formulated, how graphs and tables are used to present data, how experiment is designed *etc.* to focus on the desired learning outcomes of SPSs, performance-based assessment, and instructor feedback. The participants worked in groups of 4 or 5. Most of the activities were easy to perform, required little class time, and could easily be modified to their classes in the future. Table 1 briefly compares the traditional LASE-I course with the R-LASE-I course in which an instructional intervention was performed during the study.

Table 1. Comparison of the traditional LASE-I course and the R-LASE-I course

LASE-I course	R-LASE-I course
1. Traditional laboratory experiments were followed as cook-book. Practical activities were usually performed to confirm the theories or concepts.	The learning science process was integrated into the flow of traditional LASE-I course. An instructional intervention was performed by putting purposively emphasize on science process through inquiry-oriented activities. Multiple types of experimental activities from closed-ended to open-ended were used.
2. The PSTs worked in traditional groups of 4 or 5.	The PSTs worked in groups of 4 or 5. A cooperative learning technique was employed. Each group member had roles as recorder, spokesperson, responsible for material etc. and they rotated roles periodically.
3. Content knowledge of science was focused. Procedural knowledge and understanding of science were ignored.	Knowledge and understanding of the content and processes of science were integrated.
4. Improving process skills of science was not purposively emphasized.	Improving process skills of science was purposively targeted.

Additionally, a sample of intervened activity is presented in APPENDIX. Some laboratory activities practiced within the R-LASE-I course are given in the Table 2.

Table 2. Some of the activities intervened over the study

Name of activity	Objectives of science content	Objectives of science processes	Procedure
Let's become a nutrition detective	Describing the basic chemical composition of carbohydrates, proteins, fats, and vitamins	Comparing and classifying; identifying similarities or differences, critical thinking	Given a question, materials, procedure, and Predict-Observe-Explain task
Is Ayse's wristlet made of pure gold or imitation?	Defining density, and applications of it	Designing a measurement procedure; measuring; obtaining a value of a derived quantity (density)	Given a scenario and materials

Let's know properties of the soil around us.	Using pH concept, learning some qualitative *analysis techniques*	Designing equipment for collecting data; collecting and recording data; making and interpreting tables and/or graphs	Given a question
The car moving to the farthest is looser!	Identifying the force of friction, learning how friction and surface texture can increase and decrease motion.	Identifying and controlling variables; describing relationships between variables; exploring how a dependent variable changes when each of independent variables changes	Given a question
Let's Design an Experiment (Two of the problems given are below: *Problem 1*: *Mr. Ali needs your help* Ali uses antacid drug because he suffers from stomach-aches. Ali wants to take the antacid drug by dissolving it in water. Please help Ali, 'what affects the rate of dissolving?' *Problem 2*: Your friend says he/she uses laundry soda instead of calgon in laundry machine. Which one is more effective to soften the water? Design an experiment to indicate it to your friend.	Defining neutralization; defining rate of a reaction; determining what affects the rate of dissolving Defining water hardness; determining how water hardness can be removed	Designing and conducting a simple investigation	Given a scenario

PSTs were requested to design and conduct investigations through in total four task-oriented inquiry activities based on scenarios given by the instructor/researcher. Following laboratory practical activities, each lecture provided science background knowledge that explained the question under investigation and related natural phenomena. Feedback was given to the participants on their worksheets and experiment reports for each activity, and the participants were encouraged to think about the connection between scientific content knowledge and procedural skills. After completing the activities, through performance tasks, the PSTs were engaged in some aspects of science processes through specially designed 6 activity stations.

This station work was adapted from Harlen (1998) with some different activities as assessment exercises. Each PST group of 4 or 5 performed each station-activity based on worksheets including activity directions. PSTs were asked to identify one or two main targeted process/inquiry skills used in each station-activity although there would be more than one SPS for each station-activity. The five targeted SPSs were: Observing, hypothesizing, determining and controlling variables, planning investigations, interpreting findings, and drawing conclusions. Then, each PST group explained their own idea, and discussed their ideas to come to an agreement with other groups on which SPS used. Moreover, an open-ended investigation as final project was assigned to the participants at the end of the term.

Data analysis

The data were analysed through the Statistical Package for the Social Sciences (SPSS). Before comparing pretest-posttest, normality assumption with descriptive statistical values was primarily tested by using Shapiro-Wilk test (n = 36) in order to employ t-test for the paired samples (Skewness = -.471, Kurtosis = -.355, Statistic(36) = .955, p = .155 for TSPS (pre); Skewness = -.421, Kurtosis = .320, Statistic(36) = .950, p = .103 for TSPS (post)). Since pretest and posttest scores showed normal distribution (p > .05), t-test was applied for the paired samples in parametric methods to determine whether there were statistically significant differences in the pre- and posttest scores of TSPS. Obtained data was evaluated at p = .05 significance level. Moreover, considering that pencil-paper assessment might not show students' real performances on some aspects of investigative work, worksheets and/or experiment reports reflecting the PSTs' performances were also assessed quantitatively by determining the accuracy of statements and/or by using the scoring criteria developed by Temiz (2007) as mentioned before. For example, skills of identifying problem, identifying dependent and independent variables, and formulating hypothesis were assessed by determining the accuracy of statements (*1 point* for each *correct* response) on their reports and/or worksheets. For the skills of controlling variables, it was expected that maximum 4 variables were determined (1 point each). Participants' performance related to the skills of designing experiment, collecting-recording data and modelling were assessed in the sense of both process and product by utilizing the analytic criteria scale of designing experiment, the tabulating data skills test (TDST), and the checklist of line graph measuring the scoring criteria developed by Temiz (2007) as mentioned in *Data Collection Tools* section. In context of the skill of choosing proper materials in order to set up the experiment, PSTs were expected to determine maximum 7 experimental materials (1 point each) in order to assess the skills of identifying and using experimental materials. Also, for the skill of analyzing data, c*orrect answers* were scored as *4 points***,** partial correct/acceptable answers were scored as 2 points, and incorrect or blank *answers were* scored as 0 *point.* The worksheets and/or experiment reports were rated independently by the researcher and an expert on the science education, and the inter-rater reliability of the performance assessment was established as r = 0.819 at the .05 level. *A* Pearson Product Moment Correlation Coefficient (r) was also calculated between the posttest score of TSPS and the performance-based assessment scores measured with either by determining the correctness of the statements on the worksheets, or assessing through the criteria developed by Temiz (2007). Furthermore, frequency and percentile values of the distribution of the students' responses about the course were calculated. The worksheets and/or experiment reports of the participants were examined qualitatively to provide information on the problems using SPSs.

Results

The results are displayed below by referring to the questions respectively.

(1) Did the SPSs levels of PSTs enhance significantly at the end of the instructional intervention?

In order to analyse the TSPS data, paired sample t-test was used to investigate whether the participants could enhance their level of integrated SPSs. Although the number of participants was n=38, two participants did not complete the posttest. Therefore, the final number of the participants was 36. The means and standard deviation of TSPS for both pre- and posttest are given in Table 3.

Table 3. Results for paired sample t-test of TSPS

	n	X(mean)	SD	Df	t	p
Pretest	36	62.222	4.008	35	10.668	.000*
Posttest	36	68.389	2.464			

Note: *p< .05

According to Table 3, a significant difference between the pre- and posttest scores of the participants' SPSs was found ($t(35) = 10.668$, $p < .05$). When the means of pre- and posttest (X(pre)= 62.222; X(post)= 68.389) were examined, it was seen that the effect of the R-LASE-I course on the participants' SPSs was in favour of the posttest.

Furthermore, the frequencies and percentages for the 36 items on the TSPS for both pre-and posttest were analysed in order to determine which item(s)' rate of correct responding percentage is less than 50%. Consequently, for this sample, the items whose rate of correct responding percentage lower than 50% were 13, 15, 18, 30th item (identifying variables objective), and 27 (an identifying and stating hypothesis) in the pretest. On the other hand, it was found that the rate of correct responding percentages of 13, 15, 18, 30th items was 50% more successful in the posttest. However, for item 27, while the rate of correct responding percentage was 36.1% in the pretest, only 44.4% of participants correctly answered in the posttest. To sum, the lowest rate of correct responding percentage was 44.4% for item 27 in the posttest.

(2) Was there a significant correlation between the scores of the TSPS and performance-based scores of the PSTs?

A Pearson product moment correlation coefficient (r) was calculated to examine whether there was a significant correlation between the posttest score of TSPS and the performance-based assessment score. At the end of the R-LASE-I course, the experiment reports and/or worksheets were also assessed quantitatively by determining the accuracy of statements and/or using the scoring criteria developed by Temiz (2007) as mentioned before.

The worksheets and/or experiment reports were rated independently by 2 raters and the inter-rater reliability of the performance assessment was established as $r = 0.879$ at the $p < .05$ level. According to the result, a significant positive correlation at the $p < .05$ level was found out ($r = 0.769$) between the scores of TSPS and performance.

(3) What were the problems of the PSTs in using SPSs?

The results of the assessment based on performance of open-ended task are reported in Table 4 below.

Table 4. The results of the assessment based on performance of open-ended task

Targeted skill	Percent of response
Hypothesis is formulated correctly.	77.77
Dependent variable is identified correctly.	88.88
Independent variable is identified correctly.	66.66
Controlled variables are determined correctly -4 and more controlled variables are determined correctly. -3 controlled variables are determined correctly. -1 controlled variable is determined correctly.	 22.22 66.66 11.11
All materials required of their experiments could be described obviously.	88.88
Data table and/or graph is/are formed.	100.00
Title of table and/or graph is written.	22.22
Data is recorded both forming a table and graph.	50.00
Replication is made. -3 replications are made. -2 replications are made.	 0.00 25.00
Data is correctly and interpretively interpreted.	100.00
Conclusion is drawn correctly.	100.00
Statement is written whether data obtained is supported the hypothesis.	69.4

Examining the worksheets and/or experiment reports according to the correctness of the statements and/or using the criteria developed by Temiz (2007) revealed the PSTs had some problems as listed below:

1- Concepts of dependent and independent variables were confused with each other, and they were used interchangeably. For example; one PST stated that *distance is dependent variable* instead of independent variable in the activity of *the car moving to the farthest is looser*.

2- Non-descriptive variable names were used. For example; one PST defined only *x* matter instead of the kind of matter, matter mass or volume as controlled variables of the problem *what affects the rate of dissolving?*

3- Possible relation between dependent and independent variables was not indicated while formulating a hypothesis and more than one independent variable was used. For example; one of the PSTs expressed that *my hypothesis is: temperature affect*, and other PST mentioned that *kind of liquid and temperature affect the viscosity of the liquid* in the activity of *what affect the viscosity of a liquid*.

4- Titles of tables and/or graphics were not either written or appropriately written. For example; one participant wrote just *Data Table* as the title of the table.

5- Experiment was not replicated.

(4) What were the opinions of the PSTs about the effect of the R-LASE-I course process on enhancing SPSs?

Opinions of the PSTs were gathered from the question form consisted of 3 parts.

For part one, the percentile values of the responses distributed to some of 19 questions about the opinions of the participants on the R-LASE-I course process are displayed in Table 5.

Table 5. Some opinions of the PSTs about the effect of the R-LASE-I course process of the first part

Items	Yes		Somewhat		No	
	f	%	f	%	f	%
Such lab implementations were exactly new for me	19	50	11	28.9	8	21.1
I prefer the implementations of lab as before	16	42.1	10	26.3	12	31.6
Such lab implementations were more tiring	17	44.7	14	36.8	7	18.4
I did not understand concepts of scientific process skills	2	5.3	8	21.1	28	73.7
The course session was effective on improving my own scientific process skills	23	60.5	12	31.6	3	7.9
My confidence increased on conducting science research	18	47.4	16	42.1	4	10.5
I can use what I learned at a scientific study	25	65.8	13	34.2	-	-
I want to study a research in more detail	23	60.5	9	23.7	1	15.8
I noticed my inadequacies' of using the scientific process skills during the course	28	73.7	9	23.7	1	2.6
I understood much better on what I should pay attention in order to develop SPS of my own future students	31	81.6	6	15.8	1	2.6

When Table 5 is examined, it is seen that, for example, 47.4% of the participants affirmed that their confidence increased while conducting science research, 60.5% of them stated that they wanted to study a research in more detail, 60.5% of them answered that the course session was effective on enhancing their own SPSs, 73.7% of them confirmed that they noticed their inadequacies of using the SPSs during the course, and 81.6% of them stated that they understood much better on what they should pay attention in order to develop SPSs of their own future students.

Results obtained from the second part of the survey are shown in Table 6.

Table 6. Responses of the participants about the effect of the R-LASE-I course process of the second part

Survey questions	Responses					
	I understood this subject very well before this course session		I now understand this subject much better		I still don't understand this subject very well	
	f	%	f	%	f	%
Formulating hypothesis	6	15.8	31	81.6	1	2.6
Defining dependent variables	3	7.9	33	86.8	2	5.3
Defining independent variables	3	7.9	33	86.8	2	5.3
Defining controlling variables	3	7.9	30	86.8	5	13.2
Developing appropriate controls for an experiment	11	28.9	27	71.1	-	-
What makes a hypothesis testable	4	10.5	32	84.4	2	5.3
Importance of replication of the experiment	20	52.6	18	47.4	-	-

According to the results of the second part in the question form, most of the participants (81.6%) indicated that they understood how to state a hypothesis much better during the course, and the 86.8% thought that they understood how to identify dependent and independent and controlling variables after the course. It was remarkable that although 52.6% stated that they knew the importance of replication of the experiment before this course session and 47.4% of them understood this subject much better via this course, according to data obtained from their performances, nobody made at least 3 replications while only 25% of them made 2 replications.

The open-ended question section as the third part of the question form was examined. Some responses about effect of the R-LASE-I course process and recommendations for the future of the PSTs are quoted below:

One PST said that *I had a lot of useful knowledge with even experiments which we firstly thought how simple they were. I learned that I should look to issues more perceptively and critically*.

Another PST expressed that *the experiments, in general, were not difficult, but we concluded deeper understandings because we thought more on them. On that account, the course was useful for me. I saw that I had much inadequacy of SPSs even with much simple a candle experiment.*

Most of the PSTs recommended to have the LASE-I course for the next year that *if activities or experiments are chosen from elementary science and technology textbook, it will be more useful on how to enhance SPSs of our own students' in future*.

PSTs' responses to the difficulties because of performing the instructional intervention within the LASE-I course are identified as follows:

One of the PSTs stated that *designing an experiment was a new thing for me; we had done experiments like cookbook by this time. Therefore, we had difficulty in determining a problem and conducting an experiment because we did not know what we would do.*

Another PST said that *I had difficulty in determining variables, formulating a hypothesis, and designing an experiment because this was the first time we applied those in this lab*.

The other PST expressed that *I had difficulty in defining dependent, independent, controlling variables, and designing own experiment. I was unfamiliar with such working; we were comfortable doing experiment before because everything was ready in front of us*. Someone stressed that *such working was not difficult but more time than usual was needed to perform.*

Another PST reported that *I could determine controlling variables, but noticed that I could not control those by doing experiment*.

In the light of the results obtained, it is possible to suggest that the R-LASE-I course had a positive effect on the PSTs in enhancing their SPSs.

Discussion

This study was conducted with the aim of enhancing the SPSs of PSTs via the instructional intervention. During the study, procedural understanding and knowledge as well as the content knowledge -which are necessary to interpret tests, recognize and explain relationships, and provide analysis-, were highlighted. It was expected that the instructional intervention by putting an emphasis on science process through inquiry-oriented laboratory activities would enhance the SPSs of PSTs.

In relation to the first set of data, a significant difference was found between pre- and posttest with respect to TSPS. Considering the results of statistical analyses given in the Table 3, it is possible to suggest that the R-LASE-I course had a positive effect on the enhancement of the PSTs' integrated SPSs. There are many studies in science literature indicating that targeted SPSs have been gained via a course in which the focus was explicitly on SPSs (e.g. Akben, 2015; Coil, Wenderoth, Cunningham, and Dirks, 2010; Etkina, Karelina, Ruibal-Villasenor, Rosengrant, Jordan, and Hmelo-Silver, 2010; Spektor-Levy, Eylon, and Scherz, 2009). According to these studies, the participants who were exposured to planned intervention could have significant gains in the mastery of SPSs with respect to the students who did not enroll 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 that SPSs might be enhanced gradually, if it is well emphasized during courses.

In this study, frequency and percentile values were also calculated for each item in the TSPS. In the light of descriptive statistics for scores on the pre- and posttest, it was found that in the pretest, the weak process skills of the participants were identifying variables and stating hypothesis skills. The results showed that the lowest rate of correct responding percentage was 44.4% for item 27, a stating hypothesis, in the posttest. The results support Windschitl's (2003) conclusion that all participants of the study (6 secondary PSTs) had difficulty formulating questions or hypotheses to investigate.

It should be stated that this study had some limitations such as it had no control group, the sample size was small, and the analysis of the long-term PSTs' outcomes of SPSs was lacked. As it had a one group pre-post test preexperiemental design, there were some testing effects including history, maturation, and regression. Although extraneous variables were not controlled in this study, and thus the results indicated a slight effect in terms of the tested innovation, the results of the study also suggested that the instructional intervention had a potential to enhance the SPSs of the PSTs.

In relation to the second set of data, when the scores of the TSPS and the performance-based scores of the PSTs were compared, a significant correlation was found. The participants became more aware of the SPSs, and they gradually moved from applying their experiment step by step to enhance their own SPSs during the semester. However, based on literature, Germann, Aram, Odom, and Burke (1996) reported that a low correlation was found between results assessed by paper-and-pencil tests and results based on performance from practical laboratory examinations. Although the participants tended to overstate their confidence as an experimental investigator as seen in Table 6, the results of performance-based assessment showed that they still had difficulty in conducting an open-ended investigation. This is not surprising as either they were not or a few was exposured to open-ended investigations during their previous education. Taking into consideration that education reform in Turkey has been implemented since 2005 for elementary schools and 2009 for secondary schools; it is possible to claim that all of the participants in this study did not have background of inquiry or open-ended research during their elementary and secondary education. Enhancing SPSs of them who have brought up with cook-book type lab courses and did not adequately have these skills is a real problem. Therefore, more guidance at strategic points via instructional interventions and scaffoldings would be very useful in helping PSTs to overcome difficulties through courses such as LASE-I or other courses in the education faculties. It is a need to consider that SPSs will enhance as long as they are used. Therefore, it is proposed that performance-based assessments should be implemented longitudinally. Hammann, Phan, Ehmer, and Grimm (2008) used three different test formats in order to identify the biology students' skills in designing experiments. They concluded that open-ended and performance-based tests were more successful in determining student success in more detail. Performance tasks reflect better the level of SPSs and difficulties which were encountered while practicing science.

The study results also revealed that there were several problems encountered while using SPSs as expressed before. Similarly, previous studies have reported that pre-service teachers had difficulty in *identifying variables* (dependent, independent, and controlled variables), *analyzing data and graphing*, and *designing experiments* skills (Ateş, 2005; Bolat, Türk, Turna, and Altınbaş, 2014; Ercan and Taşdere, 2011; Etkinaet al., 2010; Hammann et al., 2008). Additionally, as seen in Table 4, the participants did not actually take the time to repeat their own investigations. The reasons might lie prevalent behind 'cookbook' type of laboratory courses. However, focusing on a positivist view of science, it can be suggested that a confronting change is necessary to provide a level of disequilibration to a learner.

In relation to the third set of data, the PSTs had positive views about the course session. It was expected that participants taking the general chemistry –physics–biology laboratory I and II courses through two years would have grasped the process skills of science, however; they stated that, after the course, they developed a better understanding of the process of science than previous laboratory sessions. In the light of the researcher's observations during the study, the implementations performed at the beginning of the semester were interesting for the participants. However, it was seen that they had difficulty with the integrated process skills, and they were discouraged. This observation corroborates the ideas of Etkina et al. (2010), who expressed that although students provided scaffolding by means of lab handout drawing their attention on the elements of scientific process (or on specific scientific abilities), they struggled first to generate possible designs, implement their own designs, and evaluate the results. Likely, Akben (2015) who asked pre-service teachers to design inquiry-oriented laboratory experiments having different openness levels in order to develop SPSs mentioned that the pre-service teachers' anxieties of process were getting decreased and their self-confidences were getting increased gradually over the study. In the present study, despite the difficulties encountered in conducting an open-ended investigation, the PSTs took courage and actively participated in the performance tasks late in the semester when they noticed enhancement in their performance on these skills. The PSTs showed positive reflections towards the R-LASE-I course process, and they expressed that the scaffolding for using SPSs would be useful for their careers as future science teachers. Additionally, they emphasized the need to perform the experimental activities on the new science curriculum, which will foster their own practices dealing with how to help for enhancing their own students' SPSs in the future.

Although science educators have suggested that many benefits (such as scientific practical skills and problem solving abilities; scientific habits of mind; understanding of how science and scientists work; interest and motivation) acquire from engaging students in science laboratory activities, this has not yet been realised for more than a century of promotion of lab works (Dillon, 2008; Hofstein and Mamlok-Naaman, 2007). It can be offered that *how* a laboratory activity can be practiced is more important than *what* laboratory activity can be used in a laboratory class. The important issue might be that there can be matchup aims of the laboratory activities and instructors' intentions to improve students' SPSs. Effective learning of scientific investigation processes requires using the structure of particular scientific frameworks including framing questions, formulating hypotheses, constructing comparisons in data, and evaluating hypotheses. In order to learn scientific processes, students need to understand how the general strategies of science (controlling variables, discriminating hypotheses) are realized within particular scientific domains (Reiser, Tabak, and Ucla, 2001). Targeted practical tasks can be very useful for developing specific understandings about data, experimental planning, and data interpretation. How successful any given practical work task depends on the intended learning objectives of the task (Millar, 2004). At this point, it should be noted that since PSTs did not have any previous experiences in SPSs, we should not expect meaningful outcomes of inquiry-based learning in the science teaching courses unless we provide them opportunities to enhance their process skills. The PSTs can enhance SPSs through integrating the outcomes of science processes into traditional laboratory course.

Conclusion

The aim of this study is to investigate the effects of an instructional intervention on enhancement the pre-service science teachers' (PSTs) science process skills (SPSs), to identify the problems encountered in using SPSs, and to determine the opinions of the PSTs about the R-LASE-I course process. The following conclusions can be drawn from the present study:

1. The SPSs of the PSTs were enhanced significantly at the end of the instructional intervention.
2. A significant correlation between the scores of the SPSs test and performance-based scores of the PSTs was found.

3. The PSTs had some problems in using SPSs.
4. The PSTs had positive opinions about the effect of the R-LASE-I course process on enhancing SPSs.

Based on the results of the study, it is possible to suggest that the instructional intervention integrating the learning science processes into the traditional laboratory course had a positive effect on enhancing of PSTs' SPSs. However, the small sample size and the non-existence of a control group make it hard to generalize the conclusions. Further studies need to be conducted to better understand whether putting an emphasize on targeted SPSs via an instructional intervention embedded inquiry-oriented activities is useful or not in order to enhance SPSs of PSTs through science teaching laboratory applications courses in education faculties alike.

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Appendix

A sample laboratory activity within the traditional LASE-I course

Title: *Determining density of a solid object having an irregular shape*

Aim: *To determine density of a solid object having an irregular shape*

The outcomes of lesson: *Understanding density concept*

Materials: *An irregular solid object, 100 mL graduated cylinder, balance*

Procedure:

1. *Measure and record the mass of the irregular solid object.*
2. *Add 50 mL water to the graduated cylinder.*
3. *Record the initial volume V1 of water.*
4. *Carefully place the object to the graduated cylinder.*
5. *Record the final volume V2 of water plus object*
6. *Calculate the density of irregular solid object.*

Conclusion:

Density of the irregular solid object =

The laboratory activity intervened within the R-LASE-I course

Title: *Is Ayse's wristlet made of pure gold or imitation?*

Aim: *To provide students with a way to actively participant practical activityassociated with learning density as which is one of the distinguishing properties of matter by emphasizing some science process skills.*

The outcomes of lesson: *Understanding density concept and applications of it, and applies this concept to interpret and analyze phenomena. Developing and understanding science processes used to gather and organize data and applies them* *to explore and describe objects and events in the environment.*

(A scenario was given)

Is Ayse's wristlet made of pure gold or imitation?

One of the friends Ayse's gave her a wristlet as birthday present. Ayse wonders whether the wristlet is made of pure gold or imitation. Can you help Ayse to figure out?

(First, content knowledge of science was discussed with class. For example: What is a pure substance? What is a mixture? How do you know whether a matter is pure or mixture? What are the distinguishing properties of a pure matter? Think about what you can do with the materials given to help Ayse? How can one test for purity of a matter? Find ways to figure out density of a matter which does not have a certain geometric shape and dissolve in water. Design a measurement procedure and obtain a value of a derived quantity (density). Explain how you can use these data for determining the purity of matters.)

Materials: *Wristlet, water, 100 mL graduated cylinder, balance*

(The research question was discussed with class before it was presented)

Research question: *How can I figure out whether Ayse's wristlet is made up of pure gold?*

(The purpose of experiment was discussed with class before it was presented)

Purpose of the experiment: *To determine the density of a matter and use the data for evaluating that whether the matter pure or mixture; to understand and use science processes to gather and organize data of the density, and to apply this knowledge to explore and describe objects and events in the environment.*

(A hypothesis was asked)

My hypothesis is:

(It was discussed with class about what data we need to obtain in order to figure out whether the wristlet is made up of pure gold or not. Next, an opportunity was allowed to find their own procedure for their experiments in written, and then a copy was given -bold added for emphasis on outcomes of SPS-)

Procedure:

1. **Measure** and **record** the mass of wristlet on the table.
2. Add 50 mL water to the graduated cylinder, and **record** the initial volume V1 of water.
3. Carefully place the wristlet to the graduated cylinder.
4. **Observe** carefully the final volume of water and **record** all your observations.
5. **Record** the final volume V2 of water plus the wristlet on the table.
6. **Calculate** and **record** the difference between the initial volume and the final volume of water.
7. **Calculate** the density of the wristlet.
8. **Repeat** above steps for 3 times and find an average data.
9. **Record** the density of gold from resources on the table and **compare** it to established value.
10. **Make a decision** whether the wristlet is made up of gold or not.
11. **Present evidence** of your decision.
12. **Evaluate** your hypothesis.
13. **Compare** the data with class.
14. **Discuss** sources of error.

My observations: *(Please write all your observations in detail)*

(Table was given to record their data)

Table 1. Data related to the wristlet

Trial	**Mass of the wristlet (g)**	**Difference of the level water (cm3) (V_{final}-$V_{initial}$)**	**Volume of the wristlet (cm3)**	**Calculate of the density (g/cm3)**	**Density of pure gold**
1.					
2.					
3.					
Average					

(It was discussed with class on how to analyze the data)

My decision: ....
My evidence: ....
Conclusion: ………………
My hypothesis is (not) supported ……………………….
Sources of error may be ……………………….

(Discussion after the experiment: What were the most difficult aspects of conducting this experiment? What would you do differently in conducting an experiment on how we can use density property for determining that a matter is pure or mixture with together your own students in future?)