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Inquiry-Based Laboratory Practices in a Science Teacher Training Program

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In this study, the effects of inquiry-based learning practices on the scientific process skills, creative thinking, and attitudes towards science experiments of preservice science teachers have been analyzed. A non-experimental quantitative analysis method, the single-group pre test posttest design, has been used. In order to observe the scientific skill level development of pre-service teachers, the Scientific Process Skills Test and experiment worksheets have been used. Furthermore, the Torrance Test of Creative Thinking has been used for determining the development of creative thinking levels and to specify the development of attitudes towards science experiments, the Attitude Scale towards Understanding the Purpose of Science Experiments has been used. At the end of the study, it was determined that inquiry-based laboratory practices improved the scientific process skills and all creative thinking levels and attitudes towards science experiments of pre-service science teachers.

Keywords: inquiry based learning, laboratory applications, scientific process skills, creative thinking, attitudes toward science

INTRODUCTION

The place of science in our lives is obvious as has been stated by Jacob Bronowski (1978), a mathematician, science philosopher, and teacher, who claimed that the biggest invention of the scientists is science itself, (cited in Williams, 1994). Today, as science directs all development, people are chasing knowledge faster and faster to keep power in their hands. However, keeping the increasing mass of knowledge in mind, it is getting more important to choose the necessary knowledge and use it at the right time and in the right place. Therefore, science education in particular is of great significance. Science education that aims to improve the sense of curiosity and research instincts of students also aims to educate individuals that have the skills of scientific and rational thinking: analyzing, questioning, searching for knowledge rather than memorizing, using and sharing this knowledge, creating, exploring, producing, and having communication skills and the ability to work in a team (NRC, 1996).

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One of the responsibilities required in the world of developing technology and knowledge is to keep up with improvements. Individuals should be literate in science in order to be able to choose the information they need and develop new information. This will also lead them to think scientifically and use technology.

The National Research Council (NRC, 1996) defines scientific literacy as a requirement for understanding knowledge, scientific concepts, and processes; making personal decisions; joining cultural and civil events; and being economically productive. Scientifically literate people search the topics they are curious about and get information about them, and then they can use this information to solve the problems they encounter. They can also define the underlying problems of national or local decisions and analyze these situations in ways that include scientific or technological knowledge (Bybee, 1997).

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State of the literature

- Teaching through inquiry is thought to promote scientific literacy and has the potential to improve both student understanding of science and engagement in science.
- Inquiry-based laboratory learning enables the learners who take part in the process to actively use problem-solving skills, to associate the knowledge gained in their daily experiences, and to develop attitudes and skills in order to generalize this knowledge.
- Teaching by using the inquiry approach is very complex and requires from the teacher different kinds of skills and a high level of expertise.

Contribution of this paper to the literature

- In this study, the effects of inquiry-based learning practices on the scientific process skills, creative thinking, and attitudes towards science experiments of pre-service science teachers have been analyzed.
- The results acquired from this study will contribute to science education and these results will shed light upon laboratory practices taking place in Science Teacher Training Program.
- In order to enhance their quality in science teaching, preservice science teachers should be supported to develop a novel approach regarding content knowledge and pedagogical knowledge.

Scientific literacy was defined by the Program for International Student Assessment (OECD, 2004) using these three qualifications:

1. Defining scientific problems: differentiating topics that can be searched scientifically, determining key words while searching scientific knowledge, and distinguishing the basic properties of scientific research.

2. Defining scientific facts: applying scientific knowledge under given conditions, defining or commenting on events scientifically, and understanding changes.

3. Using scientific proof: interpreting scientific proof, deducing and expressing results, finding evidence to support the proof and the hypothesis, and expressing the applications of science for public and technological developments.

Abilities regarding questioning, researching, and evaluating the results of studies that were issued within the PISA (OECD, 2006) survey and that are important for science education, are also present in National Science Education Standards (NSES). The importance of inquiry-based learning practices is mentioned in these standards. It is emphasized that learners will be better at identifying the condition of the problem, deciding on which data to gather and which procedure to follow, and determining the results of the study according to the data they get thanks to these practices (NRC, 1996).

According to Novak (1964), research is the behavior of making an effort to find out meaningful explanations concerning issues that people are curious about. Research requires practice and skills but the actual focus is to inquire in order to get information or the will to understand how to satisfy a concern. For this reason, the use of laboratories in science education is especially substantial. They are the practice areas of research offering practice opportunities for learners while enabling these individuals to improve their skills (Saunders, 1992; Lunetta, 1998; Temiz, Taşar & Tan, 2006). The laboratory is the place where science is figuratively put forth and where students search the natural world. Students comprehend the explanations of objects in the nature, scientific principles, experimenting, and the process of dealing with science and learning through laboratory applications (Wallace, Tsoi, Calkin & Darley, 2003). Laboratory applications, which make learning through senses possible, enable students to apply scientific research methods used by themselves while acquiring scientific knowledge.

Many studies emphasize the importance of student-centred approaches during the learning process (Brady-Orcutt, 1997; Douglas, 1997; Freedman, 1997; Kula, 2009; Wu & Hsieh, 2006; Wu & Krajcik, 2006). Learning through inquiry is one of these approaches. Thanks to inquiry-based learning, learners get closer to the topics they search, so these applications help learners strengthen their cognitive structure (Saunders, 1992). Through research-based learning applications, the scientific process skills of the learners also develop and they work in cooperation with others involved in the research (Krystyniak, 2001).

In Science a Process Approach (SAPA), a project that develops science education programs, scientific process skills are defined as the skills that can be transferred to other areas and that reflect the behavior of the scientists (Padilla, 1990). Students learn doing scientific research by observing like a scientist, making classifications and measuring, trying to deduce, putting hypotheses forward, and experimenting in the science laboratory. From this aspect, Burns, Okey, and Wise (1985) state that students can carry out research like a scientist does, if they have these scientific process skills.

Scientific process skills are the basic skills that help learning, teach methods of discovery, actively include the students into the learning process, improve their responsibilities, and help them configure practical studies. The improvement of the creative thinking skill of the individual is also important in the development of all these skills. The state of the problem and the generation of hypotheses are parts of scientific process skills and in order to improve these skills, their creativity should also be developed (Temiz et al., 2006; Şahin

Pekmez, Aktamış & Taşkın Can, 2010). The definition of creativity varies according to different areas of science and scientists.

According to Torrance's (1962) definition, creativity is accepted as a process of intuition. It is necessary to use the creative thinking skill in order to sense the severities and the problems felt in the natural process of life, the gaps in getting information, the annoying or missing elements. In addition, one should construct hypotheses and thoughts about these senses, test these hypotheses, compare the results, and change these hypotheses to test again (Saeki, Fan & Dusen, 2001).

The effect of the students' attitudes towards science is also important in developing their scientific process and creative thinking skills. Attitude, defined as an individual's positive or negative reaction to a stimulant, generates a great part of affective domain behavior (Oppenheim, 1992). It is important for the students to be actively involved in the learning process in order to develop positive attitudes towards science. Therefore, involving the active participation of students and applying scientific research steps, together with a teacher who plays an important role in this process are essential to effective science education.

Educators have done research about how they can encourage students towards understanding the nature of scientific processes which are dynamic and constantly changing (Barkley, 2010; Khishfe & Abd-El-Khalick, 2002). Moreover, Bybee (1997) has emphasized that teachers who adopts research-oriented learning will base their work on scientific principles. Moreover, they will also be able to think creatively.

Improving the existing skills of scientific process of teachers, and improving their creative thinking skills and attitudes towards science teaching are also important elements of teacher training. In this study, the effects of applications of inquiry-based learning on the scientific process of pre-service teachers, their creative thinking, and their attitude towards science experiments have also been analyzed. While it is common to come across studies concerning laboratory applications based on inquiry (David & Zohar, 2009; Duban, 2008; Grady, 2007; Wyatt, 2005), it is a rather new issue in our country. The fact that having individuals acquire ways of reaching information has become the most important aim of the new science and technology teaching program which began in 2005 in our country has also increased the importance of inquiry-based learning. Different methods and techniques have been employed in order to make learning permanent, to lead lessons in a more productive way, and to get the attention of students during the teaching process. Teacher training has great importance from this aspect. Teachers should be aware of their own and their students' learning and they should guide their students during the learning process (Barnes & Barnes, 2005).

In order to talk about the efficiency of laboratory applications in elementary education, it is necessary for pre-service teachers to be able to use their scientific process skills and to be able to transfer these skills and knowledge to their students. For this reason, the efficiency of science laboratory lectures that are available in teacher training programs should be increased so as to change the attitude of pre-service teachers towards science experiments and to improve their creative thinking and scientific process skills. It is possible that laboratory studies can contribute to making negative attitudes and bias of pre-service science teachers towards science experiments more positive and that these lectures may be more attractive and enjoyable for pre-service science teachers. Thus, while the attention and learning interest of pre-service science teachers towards science are increasing, their feelings of confidence regarding their knowledge and skills is going to develop (Lord & Orkwiszewski, 2006). Correspondingly, it may be expected that the quality of science education will increase with teachers who can improve themselves, who can produce new ideas and who can efficiently use the skills that they have in teaching. Considering these concerns, the present research focuses on the effectiveness of inquiry-based laboratory practices in science laboratory course in terms of changes in pre-service teachers' scientific process skills, creativity and attitudes toward science. In this sense, it is thought that the results acquired from this study will contribute to science education and that these results will shed light upon laboratory practices taking place in teacher training.

METHODOLOGY OF RESEARCH

Participants

Thirty-six pre-service science teachers enrolled in the Science Laboratory Application course in the Spring Term of 2011 were invited to participate in the study. All of them volunteered to participate. In this study, a quantitative research method has been used in order to investigate the effect of inquiry learning activities applied in the Science Laboratory Application course on scientific process skills, creative thinking skills and attitudes toward science of pre-service teachers. In this study, a single-group pre-test/post-test design which is a scientific research pattern has been used. In a single group pre-test/post-test pattern, an independent variable is applied to a casually chosen single group. In order for the effect to be observed on a dependent variable, a pre-experimental operation (pre-test) measurement and a post-experimental operation (post-test) measurement has been utilized (Johnson and Christensen, 2000).

Research Instruments

Scientific Process Skill Test

In this study, the Scientific Process Skills Test (SPST) has been used as a tool of data collection. The Scientific Process Skill Test originated with "The Test of Integrated Process Skills 2 (TIPS 2)" developed by Burns, Okey and Wise (1985) and is used for measuring the scientific process skills of students. It has been translated into Turkish and adopted by Özkan, Geban, and Aşkar (1991). The reliability of the test is high and was measured to be 0.85. Kanlı and Temiz (2006) found the *Cronbach α* reliability co-efficient to be 0.79. The Scientific Process Skill Test is composed of five subscales and these subscales aim to test scientific process skills. These subscales are: identifying variables (12 questions), stating hypotheses (9 questions), giving operational definitions (6 questions), designing investigations (3 questions), graphing and integrating data (6 questions). During the analysis of the test, 1 point is given for each correct answer and 0 to either false or invalid answers.

Experiment Worksheets (EW)

Six experiment worksheets (EW) concerning laboratory application based on inquiry, prepared by the researcher, have been approved for this study. The EW are intended for experiments and activities which include three chemistry, two physics, and one biology topic (see Table 1).

The EW, prepared by the researcher, have been examined by six professional educators in this field and statements in the EW have been redesigned by the researcher in accordance with these professionals. These EW have been aimed at guiding pre-service science teachers in the steps of application. The EW have been prepared in such a way that they will involve the sub-dimensions of SPST. The EW, which have been filled in by students during the process, were evaluated using the "Evaluation Form of Scientific Process Skills" developed by Şahin Pekmez, Aktamış and Taşkın-Can (2010). The chapters being included within this form and of which the Pearson Correlation rate is 0.95, are Problem, Dependent Variable, Independent Variable, Controlling Variable, Hypothesis, Experiment Design, Presentation, Result and Interpretation.

The EW of pre-service science teachers have been evaluated at two different times by the researcher. Scoring the EW for the second time three weeks after the first scoring was intended to minimize the researcher's error margin. The correlation between the first and second scores of the EW was measured and the correlation parameter was found to be 0.98. This rate has shown that there is no difference between the two scorings of the test.

Torrance Test of Creative Thinking

The Test of Creative Thinking (TTCT) was published by Torrance for the first time in 1966 and it has been used in 35 different countries, in approximately 615 researches, and more than 100 master's dissertations in order to define, measure, and evaluate the creative performances of individuals (cited in Sungur, 1997). According to what Sungur (1998) stated, Torrance (1996), in his study of the reliability of the test-retest method, has found results between 0.50 and 0.93 as a result of his applications which are applied with a two- weeks duration. Aslan (1999) translated the test from English to Turkish and has worked out the reliability, validity, and language validity of the A and B forms of the test for kindergarten, primary school, high school, and adults. In these studies, the form has been translated into Turkish by three professionals and the required corrections have been made in these forms by comparing them with each other and the last shape has been given to the form. For part A of TTCT, meaningful correlation results, ranging between 0.64 and 0.86 and $p<01$, have been found. Moreover, the difference between the Turkish and English forms of the test was analyzed with a t-test. Within the scope of the reliability study of the test, internal consistency has

Table 1. Procedures utilized in the study

Week	Weekly Activities	Allocated Time
1	Presenting the research-based learning and informing the pre-service teachers about the laboratory application to be done, application of the pre-tests	4 hours
2 - 3	Carrying out, evaluating, and presenting the application "The bag that does not break the egg"	8 hours
4 - 5	Carrying out, evaluating, and presenting the application "The boat that does not sink"	8 hours
6 - 7	Carrying out, evaluating, and presenting the application "Egg science"	8 hours
8 - 9	Carrying out, evaluating, and presenting the application "Volcano"	8 hours
10 - 11	Carrying out, evaluating, and presenting the application "What does ferment like to eat?"	8 hours
12 - 13	Carrying out, evaluating, and presenting the application "Bottle biology"	8 hours
14	Application of the post-tests	4 hours
Total		56 hours

been examined by means of test-retest and *Cronbach a* correlation parameters ranging between 0.68 and 0.81 have been achieved (Aslan, 2001; Aslan & Puccio, 2006). These correlation parameters show that TTCT is reliable. In this study, the "Verbal A" part of TTCT has been used as a pre-test and post-test. The scores of TTCT are analyzed in three different subtitles. These subtitles are:

Verbal Fluency: This deals with an individual`s production of many ideas about a topic with words.

Verbal Flexibility: This expresses an individual`s flexibility of passing from one approach to another and, at the same time, it expresses whether the individual is using different strategies or not.

Verbal Originality: This expresses the idea behind the known: simplicity and anonymous. At this dimension, an individual with a high score is evaluated as having a high extent of cognitive energy.

Attitude Scale Towards Understanding the Purpose of Science Experiment

In this research, the Attitude Scale Towards Understanding the Purpose of Science Experiment, developed by Yıldız, Akpınar, Aydoğdu, and Ergin (2006), has been used for the use of illustrating the effect of inquiry-based laboratory instruction on the attitudes of pre-service teachers towards science experiments. The scale is composed of 40 questions and is a five-point likert scale involving the following levels: "I totally agree" (one point), "I agree" (two points), "Not sure" (three points), "I don't agree" (four points) and "I totally disagree" (five points) which correspond to each different attitude expression. The scores that can be obtained from the attitude scale range between 40 and 200. In order to construct the validity of this scale, factor analysis has been done to decide whether the scale measures only one structure or more structures by regarding the correlation among the items of the scale. As a result of this analysis, the scale was determined to be a single factorial model. The question total correlation parameters of questions found in the first factor have been conferred between 0.51 and 0.84 and the Cronbach α related to the 40 questions in this factor is found to be 0.96 and which shows that the reliability of this scale is high (Yıldız, Akpınar, Aydoğdu & Ergin, 2006).

Data Collection

This study was performed in the Science Laboratory Application course in the Spring Term. The experiments, based on six studies, were designed, applied, and presented by pre-service teachers in such a way that each experiment lasted two weeks within a total of 12 weeks (48 hours). At the very beginning of the study, the pre-service science teachers were informed by the researcher about how they were going to practice their studies and some sample applications were put into practice. To begin with, the Scientific Process Skill Test, Torrance Test of Creative Thinking and Attitude Scale towards Understanding the Purpose of Science Experiment were applied to pre-service science teachers as a pre-test. Pre-service teachers formed themselves into groups of three and a shared mail group was formed in order to share experiments which were applied in the research and information about applications. In this way, the researcher transmitted the experiment worksheets and the search topic before each experiment was applied. Science experiments based on inquiry were practiced by pre-service teachers between the 2nd and 13th weeks of research. During the research, experiments were prepared by students and were examined by the researcher. In each experiment, experiment worksheets in the extent of preparation, application and evaluation were studied by pre-service teachers. By creating arguments about the problem, each group decided within itself what kind of experiment they would do and together applied the steps of the experiment and observed. In addition, each pre-service science teacher filled in the experiment worksheets individually. After each experiment was completed, posters about the experiment were prepared and presented by the pre--service science teachers together. In the final week, post-tests have been applied to preservice science teachers. At the end of the term, experiments practiced by pre-service science teachers and posters prepared by pre-service science teachers were exhibited for three days at a science fair and in this way, pre-service teachers had the chance to share their studies with science and technology teachers and primary school students, educators, and other pre-service science teachers.

Analysis of Data

Data obtained from data collection tools were been evaluated using a variety of analysis methods available in SPSS 13.0. In order to be able to choose among the parametric and nonparametric tests that would be used in the evaluation of data collected from research, the single-group Kolmogorov- Smirnov Test was applied to define whether data sets show normal distribution or not (Johnson & Christensen, 2000). For the resolution of data and illustrating whether there was a meaningful difference between pre-test and post-test scores, the Scientific Process Skills Test, Torrance Creative Thinking Test and Attitude Scale toward Understanding of the Science Experiments, and paired Samples t-Test were used.

FINDINGS

This study aims to observe the pre-service teachers' development in their scientific process skills, creative thinking skills, and attitudes towards science experiments in research-based laboratory practices. In this part, the data collected through the measurements applied as the pre-test and post-test that were administrated according to the method of the study and the experimental worksheets are analyzed and the results are presented.

In order to determine the analysis method to be used in this research, it was necessary to find out whether the results of the Scientific Process Skills Test, Torrance Test of Creative Thinking, and Attitude Scale toward Understanding of the Science Experiments that were applied as pre- and post-tests were normally distributed. For this purpose, the single group Kolmogorov-Smirnov Test was applied to the data gathered through pre and post-tests. The results showed that all pre- and post-test achievements related to the three measurement devices were normally distributed (p>0.05). Thus, parametric tests were used in order to analyze the data of this study.

Effects of Inquiry-Based Laboratory Practices on Scientific Process Skills

In this study, the development of the scientific process skills were examined in five sub-categories; Identifying Variables, Stating Hypotheses, Operationally Defining, Designing Investigations, and Graphing and Integrating Data. The data on the scientific process skills gathered from the research group were evaluated through a paired sample t-test with the p<0.05 level. The results are given in Table 2.

The mean score of the pre-test of pre-service science teachers' scientific process skills is 0.75, and the pos-test average is 0.88. This result shows that there is a statistical difference between the pre and post-tests of the pre-service science teachers, and this difference is positive for the post-test (t=-9.193, p<0.05). When the data analysis of the pre-service science teachers' scientific process skills test is examined, it can be seen that the inquiry-based laboratory practices are effective in developing the scientific process skills of the pre-service science teachers. Moreover, the findings on the sub categories of scientific process skills are presented in Table 3.

As seen in Table 3, there is a statistical difference between the pre- and post-test results of the sub categories, Identifying Variables (t=-6.062, p<0.05), Stating Hypothesis (t=-5.315, p<0.05), Operational Definition (t=-3.000, p<0.05), Designing Investigations (t=-4.448, p<0.05), and Graphing and Integrating Data (t=-5.857, p<0.05) and this difference is positive in terms of the post-test.

The six experiment worksheets (EW) designed on the inquiry-based laboratory practices were examined using the Scientific Process Skills Evaluation Form in

Table 2. The t-test comparison of pre- and post-test results of the scientific process skills test of pre-service science teachers

	N	*M*	*SD*	*SE*	*t*	*p*
Pre Test	36	.751	.0974	.016	-9.193	.001*
Post Test	36	.886	.0717	.011		

*(p< .05)

Table 3. The t-test comparison of pre- and post-test on pre-service teachers' scientific process skill levels

Variable	*N*	Measure	*M*	*SD*	*t*	*P*
Identifiying Variables	36	Pre Test	0.73	.1672	-6.062	.001*
		Post Test	0.90			
Stating Hypothesis	36	Pre Test	0.73	.1498	-5.315	.001*
		Post Test	0.86			
Operationally Defining	36	Pre Test	0.76	.1666	-3.000	.005*
		Post Test	0.85			
Designing Investigation	36	Pre Test	0.87	.1623	-4.448	.001*
		Post Test	0.99			
Graphing and Integrating Data	36	Pre Test	0.75	.1328	-5.857	.001*
		Post Test	0.88			

*(p< .05)

Table 4. Experiment Worksheet' Results of Pre-Service Science Teachers

Name of the Experiment	*N*	The Lowest Grade	The Highest Grade	*M*
Bag EW	36	11	24	19.27
Ferment EW		12	24	20.38
Egg EW		15	24	20.41
Volcano EW		18	24	22.00
Boat EW		16	24	20.70
Bottle EW		20	24	23.22

Table 5. The Comparison of t-test for pre- and post-test on Pre-Service Teachers' Creativity

Creativity Sub Categories		*N*	*M*	*SD*	*SE*	*t*	*p*	The Lowest Score	The Highest Score
Fluency	Pre Test	36	33.66	15.89	2.64	-5.50	.001*	15.00	59.00
	Post Test		48.25					22.00	117.00
Flexibility	Pre Test	36	20.55	8.04	1.40	-6.06	.001*	9.00	30.00
	Post Test		29.05					11.00	60.00
Uniqueness	Pre Test	36	12.88	22.22	3.70	-8.36	.001*	2.00	29.00
	Post Test		43.86					60.00	121.00

*$p< .05$

Table 6. The Comparison of the Attitude toward Science for pre- and post-test on Pre-Service Science Teachers

	N	*M*	*SD*	*SE*	*t*	*p*
Pre Test	36	1.636	0.424	0.071	2.60	0.013*
Post Test	36	1.454				

order to specify the improvement of the pre-service science teachers' scientific process skills. The lowest mean score that the pre-service science teachers received on the experimental worksheets was 17.67 and the highest mean score was 23.17.

The results, the pre-service teachers received on the EW are shown in Table 4. The mean score of the first EW is 19.27 and the mean score of the last EW is 23.38. Thus, it is possible to say that when the average values of EW are examined, inquiry-based laboratory practices affect the scientific process skill levels positively throughout the study.

Effects of Inquiry-Based Laboratory Practices on Creative Thinking Skills

The development of the pre-service science teachers' creative thinking levels depending on the inquiry-based laboratory practices has been examined through the levels of the Torrance Test of Creative Thinking: fluency, flexibility, and uniqueness. The mean scores and the standard deviations of the pre-service science teachers' pre- and post-test results on the levels of fluency, flexibility, and uniqueness of Torrance Test of Creative Thinking were calculated (Table 5).

There was a statistical difference between the pre- and post-tests of the pre-service science teachers in terms of fluency ($t= -5.50, p<0.05$), flexibility ($t= -6.06, p<0.05$), and uniqueness ($t= -8.36, p<0.05$) and this difference is positive for the post-test. Based on this result, it is possible to say that the inquiry-based laboratory practices are effective in developing the creative thinking skills of pre-service science teachers.

Effect of Inquiry-Based Laboratory Practices on Attitudes toward Science Experiment

In order to compare the results of pre- and post-tests gathered from the Attitude Scale toward Understanding the Science Experiments that was administered to the research group, a t-test was evaluated and the results are presented in Table 6.

The pre-service science teachers' attitudes towards science experiments pre-test mean score was 1.636 and the post-test mean score is 1.454. In the attitude scale, the value of the the most positive expression is 1, and the value of the most negative expression is 5.

According to these values, it is obvious that there is a 0.013 point decrease in the pre-test and post-test averages and the p value is smaller than 0.05. This result shows that there is a significant difference of 0.05 between the pre-test and post-test results of the research group and this difference is positive for the post test. It is determined that there is a positive improvement in attitude levels toward science experiments through inquiry-based laboratory practices.

DISCUSSION

In this part, the findings collected to identify the effects of inquiry-based laboratory practices on pre-service science teachers' improvement within the scope of their scientific process skills, creative thinking skills, and the attitudes towards scientific experiments have been interpreted by means of comparing these findings to the related data gained before.

One of the important results of this study is that science experiments through inquiry-based laboratory practices have a positive effect on the pre-service science teachers' development with regard to their scientific process skills. In addition, during these applications it was observed that preservice science teachers could carry out a study by using the scientific process skills. Owing to these studies, it was determined that the pre-service science teachers in the study developed the skills of presenting a problem, gathering the data, seeing the relation in order to get to the solution, producing a hypothesis for the solution, applying the experiment properly, and recording and comprehending the data gained. In his study, Krystyniak (2001) determined that students in inquiry-based chemistry laboratories showed more improvement in scientific process skills than students in classes where traditional laboratory applications were carried out. Kanlı (2007) reported that inquiry-based laboratory practices have enhanced the pre-service teachers' scientific process skills. Also, similar findings have been obtained in many studies (Rissing & Cogan, 2008; Bliss, Dillman, Russell, Anderson, Yourick, Jett & Adams, 2007; Holbrook & Kolodner, 2000).

At the end of the process of this study, the highest level of improvement was achieved in identifying variables. According to this result, it could be said that through inquiry-based laboratory practices, the pre-service science teachers have been successful in presenting a problem, determining the problem-directed variables, and controlling the effect of the variables on the problem. In addition to this, it has been emphasized that pre-service science teachers developed their skills to think and to determine and formulate the results. Moreover, it has been specified that other subdimensions of scientific process skills of pre-service teachers showed improvement. It is possible to say that inquiry-based laboratory practices are effective because they can arouse curiosity by causing discussions about the problem and leading the learners to search, and they facilitate taking part in the process. Many studies also emphasized that students' thinking skills have improved due to the inquiry-based learning practices. Students have been more successful in comprehending and constructing the terms that are discussed in the class thanks to these applications (Rissing & Cogan, 2008; Tatar, 2006; Wyatt, 2005; Ateş, 2004; Edelson, Gordin & Pea, 1999).

Another important result of this study is that inquiry-based laboratory practices have a positive effect on pre-service science teachers' creative thinking skills, such as presenting many problems about an event and presenting many ideas in order to solve it. It might be said that inquiry-based laboratory practices must be applied more often in teacher training. A teacher who has learned how to discuss, question, and think creatively will be able to lead his students to observe from a variety of aspects. Results that are similar to this study's can be seen in by Tezci (2002) and Aboukinane (2007). In addition, it has been observed that thanks to these inquiry-based laboratory practices, pre-service science teachers have achieved the skill of looking at problems from many different aspects, which is one of the skills of creative thinking. Since learning by practicing and experience is important in science teaching, students must be able to see the different aspects of a situation and remember that there is always more than one answer to each question. Moreover, since presenting authentic ideas is one of the skills of creative thinking, it is one of the most significant skills that teachers will use in their scientific studies and teaching environment. In this study, pre-service science teachers found an opportunity to generate unusual and unique authentic ideas, problems and solutions. This process has improved their skill in presenting authentic ideas. Pre-service science teachers' achievement of this skill is not only important in their own learning, it is also important when they teach their students.

The other important result of this study is that, as a result of inquiry-based laboratory practices, positive developments in pre-service science teachers' attitudes towards scientific experiments have been observed. In these laboratory practices, all responsibilities were assigned to the pre-service science teachers. It was observed that during the process, the pre-service science teachers embraced each step of the application. Consequently, this development led to the result that pre-service science teachers' attitudes towards scientific experiments became more positive even in such a brief time as 12 weeks. In addition, the results of this study are parallel to the results of many studies carried out with inquiry-based learning (Domin 1999; Altunsoy, 2008; Taşkoyan, 2008; Kula, 2009). Since a teacher's attitude affects students' interest in class and success, it is important for pre-service science teachers to develop their attitudes towards science and scientific experiments. Those pre-service science teachers having positive attitudes towards science and scientific experiment will become more successful teachers in both academic and occupational areas.

Based on the results from this study, it is possible to say that inquiry-based laboratory studies have a positive effect on pre-service science teachers' scientific process skills, creative thinking skills, and attitudes towards scientific experiments. Inquiry-based learning enables the learners who take part in the process to actively use problem-solving skills, to associate knowledge gained through their daily experience, and to develop attitudes and skills in order to generalize this knowledge. It is quite important for science teaching and learning to develop these attitudes and skills. For this reason, in order to enhance the quality of science teaching, teachers who have positive attitudes towards scientific experiments, whose creative thinking skills and scientific process skills have been developed, and who are able to guide their students through scientific issues are needed. For this purpose, inquiry-based learning activities and laboratory activities must be applied to science teacher training programs. In addition, in our country, science teachers must be informed about this recent application and supported teaching activities.

CONCLUSION

In this study, it has been stated that inquiry-based laboratory applications have positive effects on pre-service science teachers' scientific process skills. It has been determined that inquiry-based learning applications in laboratory environments have an effect on pre-service science teachers' development of Identifiying Variables, Stating Hypotheses, Operationally Defining, Designing Investigations, and Graphing and Integrating Data, which are sub categories generating scientific process skills. It could be said that during the process pre-service science teachers have improved their skills in determining the variables in experiments to be changed or kept stable under various circumstances. These practices have helped pre-service science teachers develop their interpretation skills in correlating dependent variables and independent variables.

Another result gained from this study is that inquiry-based laboratory practices have a positive effect on pre-service science teachers' skills in describing the situation of a problem, forming a hypothesis for the solution, setting the necessary mechanism in order to test the hypothesis, and explaining how to measure the variables used in the experiment. It has been determined that pre-service science teachers have developed their measuring skills during this process. Furthermore, it has been put forth that pre-service science teachers have recorded the data they gathered in a much more reliable way by using methods such as writing and drawing pictures and graphs. In addition to this, it has been confirmed that these applications have an impact on the pre-service science teachers in terms of their improving their skills of interpreting the data that they gathered from their research, by explaining the motives of the case.

The other important result of this study is that inquiry-based laboratory practices have a positive effect on pre-service science teachers' creative thinking skills. It could be stated that pre-service science teachers have had more success in generating original ideas due to these applications. In addition, pre-service science teachers have developed their skills to form a great number of acceptable ideas or alternatives to a solution.

Finally, it has been determined that inquiry-based laboratory practices have a positive effect on pre-service science teachers' attitudes towards scientific experiments. In other words, it has been observed that pre-service science teachers had more positive attitudes towards forming ideas about experiments while they were doing the experiments.

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