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USING THE HISTORY OF SCIENCE TO TEACH SCIENTIFIC INQUIRY

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Abstract. *The aim of the research is to detect the views of the science teacher candidates about the nature of scientific inquiry before and after a history of science based teaching process. The research was made with the participation of 18 teacher candidates, who were enrolled in the primary science-teaching department of an Istanbul-based university. The qualitative data collection and analysis methods were used in the research, which was based upon the "case studies" to uncover the views in more details. Data of the research were collected by using the document analysis and interview. The data were assessed through the content and descriptive analysis methods. The results of the research represented that the teacher candidates' views about the guidance of the scientific questions to the scientific investigations, the multiple purposes of the scientific investigations and the justification of the scientific knowledge were "weak" in the pre-test, and their views about the remaining aspects were at the level of "informed." The teacher candidates could not express "sophisticated" views about any aspect. After the implementation process, it was seen that the teacher candidates' views about the method diversity and the distinctions between the data and the evidence improved, but there was no difference in their views about other aspects.*

Key words: *history of science, nature of scientific inquiry, science teacher candidate, science teaching.*

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Introduction

Students learn what science is and how scientific knowledge is acquired latently both in their daily lives and in their teaching processes. It is, however, believed that the awareness of how and by which means this knowledge is learned makes great contribution to students on their way to getting richer life experiences. Many educational perspectives emphasize that it is not enough for students to be taught through just cases, theories and laws. It is, however, teachers and educators who are interested in science, believe that students need to get knowledge and decide about how reliable a scientific knowledge is and whether this knowledge is acceptable (Bell & Lederman, 2003). We have seen many changes of great significance in the Turkish educational system as well, and the primary education curriculum has been revised from the start of the first stages of education accordingly. In this context, several new aspects have been added to the educational-teaching processes, such as science, scientific knowledge and the nature of science and of scientific inquiry. In order to be able to adapt into contemporary changes, the Ministry of Turkish National Education (MEB, 2013) emphasized the need for individuals to be raised as scientifically literate and the big role, which must be played by science classes and science teacher to meet this need.

Nature of Scientific Inquiry

The nature of science and the nature of scientific inquiry, two elements in acquiring scientific literacy are generally thought as the expressions, which refer to the same conception, although they have two different themes. This creates some misconceptions over these two concepts. While the concept of the nature of science actually refers to an "output" of an inquiry and scientific knowledge, the concept of the nature of scientific inquiry refers to a "process" regarding how the knowledge is produced and accepted (Schwartz, Lederman & Lederman, 2008). In science education, the concept of "inquiry" has different meanings upon which research method is used. The scientific inquiry includes the characteristics of the development process of scientific knowledge and the acceptance level of this knowledge as well as its usability.

Upon the criteria of scientific literacy, it must be focused on which characteristics of an inquiry a student needs to know, rather than different descriptions (AAAS, 1993). As Schwartz, Lederman & Lederman's (2008) mentioned, these characteristics are defined as scientific questions guide investigations, multiple methods of scientific investigations, multiple purposes of scientific investigations, justification of scientific knowledge, Recognition and handling of anomalous data, distinctions between data and evidence, and community of practice.

Teachers must create environments, which offer scientific inquiry experiences to enable their students to be able to develop the conceptual knowledge about the subject matter they study, to design different inquiries and to understand the characteristics of the nature of science and of scientific inquiry (Northcutt & Schwartz, 2013). Many studies, however, showed that teachers have problems with creating the required learning environments (Lederman 1992; Minstrell & Van Zee, 2000; retrieved from Lederman & Lederman, 2004 a). A learning environment, however, must offer opportunities for students to develop their own questions, to plan researches, to interpret data, and to discuss and to make conclusions in line with their fields of interests (Schwartz, Northcutt, Mesci & Stapleton, 2013). It is clearly indicated in the studies by Bell, Blair, Crawford &Lederman (2003) that the use of traditional teaching methods in the classroom by teachers makes only a limited contribution to the process and it is not enough to make science to enable students to understand the nature of scientific inquiry. This shows that some specially designed methods must be planned and implemented in the process.

General Considerations on the Use of History of Science within Science Education

As Lederman & Lederman (2004 b) indicated, any research-based activities or historical examples, which are implemented by means of explicit-reflective ways, make robust impacts on the learners' views about the nature of scientific inquiry. Matthews (1994) said that giving some space to the history of science facts in science teaching makes understanding of the scientific concepts and methods easier. The use of history of science in teaching enables people to understand that doing science is a personalized activity and it has ethical, cultural and political connotations, thus making possible for the learners to be able to understand scientific concepts and to develop critical thinking skills (Matthews, 1992). The use of history of science in teaching processes makes possible for learners to see the evolution of science in centuries, the historical steps in the production of the scientific knowledge, the life stories of scientists and the difficulties the scientists faced in their lifetimes as well as their inquiries. This method also makes students more motivated about learning science by helping them to understand the inquiries of leading scientists and to develop empathy with them (Wieder, 2006).

Several studies showed that the use of history of science in teaching makes big differences on individuals' science understandings. Irwin (2000) found that students were offered significant information about how the scientific knowledge is developed with the teaching methods, which use historical materials. As Bettencourt (1993) underlined, the teaching methods by using the history of science show how the scientific knowledge is acquired and include several theories and views of historical importance, thus helping the scientific conceptions to become easier to understand and the ideas to be reconstructed (retrieved from Galili & Hazan, 2001).

Schwartz, Lederman & Lederman (2008) said the nature of scientific inquiry is a process of doing science and these processes are often conflated or combined under a more general "students' understandings of science." Notions about the methods of science, for example, are often placed under the umbrella of "NOS." Lederman & Lederman (2005 a) emphasized that the understanding of the nature of scientific inquiry must also be examined and they explained why this was not examined properly. As teachers do not have proper knowledge about the nature of scientific inquiry, teachers usually think the scientific inquiry process can be understood by doing science. They could not implement the inquiries in the classroom, they do not understand the scientific inquiry practices or they want to make the inquiries by traditional methods.

Though history of science has an important position in science education, it does not have enough opportunity of practice due to various limitations in the teaching process in Turkey. However, history of science holds a quality, which can enable students in the teaching process of history of science to obtain direct experiences guided by the events experienced before. The practice of history of science in the process of teaching can directly serve for the objectives of science education. In addition, it is thought that the existence of history of science in the teaching process will have a very functional role in terms of the acquisition of the necessary themes for the scientific literacy. A teacher who spares time for history of science in her/his classes and gives opportunity for different headings such as the nature of science and scientific inquiry, scientific process skills, the relationship between concepts- principles- theories- laws- and –science- technology- society to be discussed in the class will have also taught many different headings in relation to scientific literacy. Paralleling the reformation movements in Turkey, the course books also started to include various historical short texts and stories. The most important problem at this point is the teachers' efficiency of using these activities. In this context, it is thought that the research will light the way for teachers and those who will do research on this topic.

It was seen that there were many international studies about the nature of scientific inquiry (Lederman & Lederman, 2004 a-b; Lederman & Lederman, 2005 a-b; Crawford, Zembal Saul, Munford & Friedrichsen, 2005; Akerson & Hanuscin, 2007; Wong, Hodson, Kwan & Yung, 2008; Grinstaff & Richmond, 2008; Lotter, Singer & Godley, 2009; Saad & Boujaoude, 2012; Schwartz, Northcutt, Mesci & Stapleton, 2013), but there were very few studies in local literature (Tuncel, 2012; Aydemir, 2012; Karaman & Apaydın, 2014). These studies included various implementations with different groups, but the findings had a number of limitations in terms of the participants, the description of the participants' views or the implementation process. Any research was not seen with the attempt of examining the impact of the history of science -based teaching on the nature of scientific inquiry. Therefore, the research would contribute to the literature by describing the effect of teaching by the history of science upon the understanding of the nature of scientific inquiry. It is also believed that the research would make a contribution as it made suggestions about how such a teaching process should be established and information about what to do during these processes.

Aim of the Study and Research Questions

In this vein, the aim of the research is to determine the views of the science teacher candidates about the nature of scientific inquiry before and after a history of science-based teaching process. In line with this aim, the sub-questions of the research were defined as follows:

1. What do science teacher candidates think about the nature of scientific inquiry before and after a history of science -based teaching process?
2. How does the history of science -based teaching affect the views of the teacher candidates about the nature of scientific inquiry?

Methodology of Research

In order to find the answers to the sub-questions in line with the aim of the research, the general research plan was based on "case study," one of the qualitative research methods. The research was implemented in 2011-2012 spring term with the participation of 18 science teacher candidates. Data of the research were collected by document analysis and interviews; and the data obtained from the data collection tools were assessed by using the "content analysis" and "descriptive analysis" methods.

Population of the Research

In the research, the method of "easily accessible sampling" selection was used owing to the implementation of teaching plan in the researchers' class. The participants of the research were elected from the class, who volunteered to take part in the research. In this context, the research was conducted with the participation of 18 science teacher candidates, 10 females and 8 males, between the ages of 18-24, who were enrolled in the primary science teaching department of an Istanbul-based university.

Model of the Research and Role of the Researcher

In the research, the qualitative data collection and analysis methods were used and the research was based upon "case study" to uncover the views in a detailed manner. Data of the research were collected by document analysis and interviews. In the research, while the document analysis was preferred for reasons such as preventing participant reactivity, providing opportunity for analysis in the practice process, making a wide sampling available and making the participants obtain individualism-originality; the interview method was preferred for reasons such as providing flexibility to the researcher, high rate of answers given to questions and ensuring the control over the environment (Yıldırım & Şimşek, 2013, p. 220, 221, 152,153).

The data obtained from the data collection tools were assessed by using the "content and descriptive analysis" methods. In the research, the data obtained from the scale practiced in order to determine the views of teacher candidates were subjected to a detailed analysis, as they constituted the foundation of the research results. In this regard, the available data were analysed with "content analysis". Data, obtained from the interview questions and video records, on the other hand, were used in order to support the data obtained from the scale and for this reason they were analysed with "descriptive analysis". Data are subjected to a more detailed analysis in content analysis and it is tried to define the data and determine the facts to be hidden inside the data. In this regard, it is needed to conceptualize the data as the first step and then to organize them in a logical way according to these concepts and to create themes explaining the data. Thanks to the themes, the phenomena are better organized and made more comprehensible. In descriptive analysis, data are summarized and interpreted upon pre-defined themes. Such data can be arranged in line with the themes, which are created by using the research questions or can be presented by taking the questions or the aspects used in the interviewing and observation processes. The data are selected to describe the situation and combined in a meaningful and rational manner. Some data can be excluded in accordance with the constructed framework. In summary, while the data are described after being summarized and interpreted in descriptive analysis; unnoticed concepts and themes in the descriptive process are explored and the results can be presented with a more detailed analysis in content analysis (Yıldırım & Şimşek, 2013, p. 256, 259).

Owing to the nature of qualitative research, in the research it was aimed to follow the research processes directly, to define the research questions, to select the appropriate data collection and analysis methods in line with the questions, to overcome any deficiencies in the implementation process and to meet the ethical conditions the researcher attended the whole process, in order to be able to conduct the qualitative research in a more efficient way. Furthermore, the findings were exemplified with one-to-one reference recordings and the data were diversified by using various data collection tools, including the video and interview recordings. The data were then encoded by another researcher after the researcher had done so as to prevent any biased interpretation by the latter during the encoding process and the consistency of the coding by the both was then calculated.

Implementation of the Teaching Plan

The research lasted eight weeks in 2011-2012 fall term and the history of science-based teaching constituted the basis of the research. The whole research was conducted upon the subject matter of "atom" which was taught in general chemistry-I course in the 1st graders curriculum. The weekly distribution of the subject matters is "the conservation of mass principle (60 min), the law of definite compositions and multiple proportion law (60 min), historical evolution of the atom (60 min), history of Rutherford experiment (60 min), historical evolution of the atomic models (60 min), historical evolution of the periodic table (60 *2 min), historical evolution of the chemical bonds (60 min)." The matters included in the research are presented with a historical content. In this regard, many topics such as which events took place, which inventions were made, how scientists worked in different periods of history were taught not independent from the historical process. In this research, where the topics are presented after being evaluated in terms of history, excerpts from history of science are mostly included, but the details related to philosophic, religious, social and economic characteristics of the period are not mentioned.

In the teaching process, the slides prepared by the researcher as being suitable to the history of the topics were presented within the class, and in this process, the aspects of the nature of scientific research were discussed with the questions posed by the researcher. Any material with historical content (texts with historical content, documentaries, articles, research activity etc.) or any different material that would require the teacher candidate to research were not used in the research.

While the researcher was presenting the historical framework related to the lesson to be covered in that class every day, he/she also asked questions, which could make the aspects of the nature of scientific inquiry to be discussed. In this process, researches of scientists were often referred to and the related aspects were discussed from this point forth. A number of questions were asked during the implementation process to the teacher candidates about how scientists worked, which scientific methods were used or how the scientists became sure about the validity of their findings.

The lesson plan about "the conservation of mass principle" is sampled below.

Aspects of the nature of scientific inquiry, which was adapted to the lesson: Scientific questions guide investigations, multiple methods of scientific investigation, multiple purposes of scientific investigation, justification of scientific knowledge, recognition and handling anomalous data, community of practice

Subjects of the Lesson: The reasons behind the delay of modern chemistry era, the classification of matter by Aristotle in the 4th century B.C., combustion theory (Phlogiston Theory) by Becher and Stahi, Lavoisier's explanation about combustion in 1783, discovering of "fixed air" by Joseph Black (CO_2), discovering of "inflammable air" by Henry Cavendish (H_2), discovering of oxygen by Joseph Priestley in 1774, Lavoisier's explanation about the effect of oxygen in the combustion in 1777, discovering the composition of water in 1783, the explanation of Lavoisier's "conservation of mass principle".

Implementation Process: The course session got started by asking why a theory gained recognition in the 17th century, although it was mistaken. After then, the teacher candidates were encouraged to discuss how scientists collect data and how they become sure about the validity of the data. The relationship between the data and the evidence was also addressed. It was also discussed how scientists discovered oxygen and similar gases, whether they adopted empirical data or observation results and which scientific method should be used in the scientific inquiry period. The teacher candidates were told how scientists exchanged views and affected each other's works in some cases.

Questions, which were asked in the implementation process: How do scientists start their studies? Which methods do scientists use to collect data? Do scientists make experiments in the whole process of their research? Do scientists use only observations in their researches or they use other methods for reaching results? What are scientists' purposes when they start their studies? What was the reason behind the acceptance of the Phlogiston theory, which was shown to be false after a century? What kind of researches do scientists conduct to demonstrate whether a theory is accurate? How do scientists decide whether a theory is accurate? Which type of methods do scientists use for the accuracy of data? Do scientists change the results of their or others' studies? Why? When scientists could not reach a result, what do they do? Do social life, culture or community effect scientists' researches? Do scientist effect each other when they conduct a research?

Data Collection

Data of the research were collected by document analysis (the views of scientific inquiry scale and video recordings) and interviews. The documents used in the research are "The Views of Scientific Inquiry Scale-VOSI" and video recordings.

Data Collection Tools

"The Views of Scientific Inquiry scale" used as a primary data collection tool in detecting the thoughts about the nature of scientific inquiry before and after implementation period. The scale was originally developed by Schwartz, Lederman & Thompson (2001). This study served as a pilot of the first VOSI form. After this, the scale was revised, to create different versions by Schwartz, Lederman & Lederman (2008). The items were examined and validated by a panel of science educators and then administered to a group of 10 grade nine students, who were also interviewed. There are VOSI forms appropriate for elementary and middle school children, secondary students, college students, preservice/in-service teachers and scientists (Schwartz, Lederman & Lederman, 2008).

The Turkish adaptation of the scale was prepared by Karaman & Apaydın (2014). The content validation of the scale was ensured by two science educators, who specialized in the field of nature of science. The language validation of the scale was also provided by two researchers, who specialized in the field of Turkish language.

The scale is composed of seven open-ended questions and aspects. The classification of the scale questions upon the aspects of the nature of scientific inquiry is "scientific questions guide investigations (1-6th questions), multiple methods of scientific investigation (1-3-4th questions), multiple purposes of scientific investigation (1st question), justification of scientific knowledge (5-6th questions), recognition and handling anomalous data (7th question), distinction between data and evidence (2nd question), community of practice (6th question)."

In order to be able to detect the teacher candidates' thoughts in the research, a series of interviews were made with seven teacher candidates at the end of the teaching process. Volunteer teacher candidates participated in the interview session. For triangulation, interviews were used to support the results of the scale. Standardized open-ended questions were used in the interview.

The interviews took 40-90 minutes and were all recorded not to lose any data. The interview questions were prepared by taking the scale questions as a basis. Additionally, a literature review was made during this process. All the questions were brought together in a question pool and the most appropriate seven questions were selected by the researcher in accordance with the targets of the research. These selected questions were then re-organized in accordance with the research content after taking the views of the three field experts. The final four interview questions were thus composed. Some of the questions are as follows: Do all scientists use the same method? How do you define a scientist? What is science? What comes to your mind when somebody talks about science?

In order to examine teacher candidates' views in a detailed way, all of the teaching processes were recorded digitally in each lesson. Video recordings were used as the secondary data collection tool to support the results of the scale for triangulation. The video recordings took 40-70 minutes and the teacher candidates were informed about why video recordings would be made and what the content of the research was before any recording was made.

Research Ethics

Before starting the research process, the groups to participate in the research were met and they were informed in a detailed way about issues, such as what purposes the research would be made with, how long it would last, what kind of data collecting instruments would be used in this process, how these data collecting instruments would be analysed, where the results would be used and how they would be reported. In the light of this information, voluntariness was based on and willing teacher candidates were made to participate in the process.

In addition, it was stated that the data obtained from the research would not be deciphered, data related to each teacher candidate would be secretly codified and recorded and therefore the private lives of the participants would be respected and not damaged. In this regard, the data obtained from both the scale and the interview questions were collected in regard to numbers given to each student and were analysed in the same way.

Besides, the teacher candidates were informed about why the video recording was being done and with what purposes these records would be used before the video recording in the research. Teacher candidates who did not want to participate in this process were not recorded in video and they were only recorded in voice. Teacher candidates were ensured on the confidentiality of the video records and that nobody else except the researcher would have access to the records.

Also, points such as that the research would not have any negative or positive effect on their academic achievement were conveyed to the teacher candidates in a detailed way.

In addition, data obtained both from the research documents and from the interview questions were included in the research with direct references and the themes obtained as a result of the analysis process were shared together with the available results.

In this regard, the conditions of "informed consent, privacy-confidentiality-free of harm and loyalty to the data" which are included in the scope of research ethics in qualitative researches were realized (Yıldırım & Şimşek, 2013, p. 122-124).

Data Analysis

In order to be able to answer the sub-questions of the research, the data, which had been compiled by means of various tools, were assessed separately and all of the findings were interpreted together.

The data obtained by using the VOSI scale, were primarily examined in detail and they were assessed by using the "content analysis" method for each question. In this vein, the questions of the scale were examined separately and the answers to these questions were encoded to compose themes. For instance, for the answers to the second question of the scale, which aims to learn whether there is a difference between a data and evidence, the following codes were obtained: "Unverified information and true or false information." Moreover, these codes were collected under the theme of "unverified information." When the encoding was made, the answers of the teacher candidates were encoded separately and the data were, thus, digitized. As some codes were voiced by more than one teacher candidate, the number of codes was more than the number of teacher candidates in the research.

The views of the teacher candidates about the nature of scientific inquiry were obtained by assessing the aspects about the nature of scientific inquiry of the themes upon the questions. For example, the findings related to the aspect of "scientific questions guide investigations" were gathered by evaluating the answers to Question 1 and 6 together. After the themes were constructed, the results were categorized according to Hughes, Molyneaux & Dixon (2012). In the aforementioned aspect; if students would say the scientific investigations start with a scientific question and scientists try to find an answer to these questions by means of different methods, they had a "sophisticated" understanding. If they would say the scientists start their scientific investigations by a hypothesis and they verify or falsify these hypotheses by means of different methods they had an "informed" understanding. If they said the scientific investigations are made by using only one method, such as experiment or observation, the candidates had a "weaker" understanding about the aspect of "the guidance of questions to scientific investigations". The classification of the themes according to Hughes, Molyneaux & Dixon (2012) is given in Table 1.

Table 1. The classification of the themes.

The Aspects about the Nature of Scientific Inquiry	Theme	Statement
Scientific questions guide investigations	Sophisticated	Scientific investigations start with a scientific question and scientists try to find an answer to these questions by means of different methods.
	Informed	The scientists start their scientific investigations by a hypothesis and they verify or falsify these hypotheses by means of different methods
	Weaker	Scientific investigations are made by using only one method, such as experiment or observation
Multiple methods of scientific investigation	Sophisticated	There are various scientific methods which can be used by scientists and if they could explain these methods adequately
	Informed	There are various scientific methods which can be used by scientists, but they could not explain what these methods are adequately
	Weaker	There is only one scientific method that is used by scientists
Multiple purposes of scientific investigation	Sophisticated	Scientific investigations have more than one purpose and elaborate what these purposes are
	Informed	Scientific investigations have more than one purpose
	Weaker	Scientific investigations have only one sort of purpose
Justification of scientific knowledge	Sophisticated	Scientists need evidences, checking techniques and the views of other scientists to verify their claims
	Informed	Scientists need to use various checking technique, including evidences
	Weaker	Scientists need to use only experiments
Recognition and handling anomalous data	Sophisticated	The anomalous data as a pusher or a new finding and they would see these abnormalities as a must for making science
	Informed	The anomalous data are attained by weaker experimental design or measurement mistakes
	Weaker	Scientists need to work in an objective way so they will not face any anomalous data
Distinction between data and evidence	Sophisticated	The distinction between the datum and the evidence and mention that the evidence is produced by analysing the datum
	Informed	The distinction between the datum and the evidence, but they could not explain what the difference is
	Weaker	The data and the evidence are the same
Community of practice	Sophisticated	Scientists may reach different conclusions by using the same methods and if they would also mention the advantages and the disadvantages of working together
	Informed	Scientists may reach different conclusions by means of the same methods, but could not elaborate
	Weaker	Scientists reach different conclusions by using different methods from each other

The data, obtained via the interviews and the video recordings, were written down on the Word program and the researcher listened to all of the recordings again to prevent any missing data. A second researcher also listened to the existing data to ensure the integrity of the data. The data obtained via the interviews and the video recordings were used to support the data of the scale for triangulation.

The data obtained from the interviews and the video recordings were assessed by means of descriptive analysis. Any data obtained through this analysis method are summarized and interpreted upon pre-defined themes. Such data can be arranged in line with the themes which are created by using the research questions or can be presented by taking the questions or the aspects used in the interviewing and observation processes. In the descriptive analysis method, the direct quotations are frequently used to the views of the individuals are interviewed or observed in a lively manner. The data are selected to describe the situation and combined in a meaningful and rational manner. Some data can be excluded in accordance with the constructed framework (Yıldırım & Şimşek, 2013, p. 256).

In this context, the existing research data were described in accordance with the themes, which were obtained from the VOSI scale and the data were presented along with the direct quotations. Some of the interviews and video recordings were excluded in accordance with the constructed thematic framework and some others were also excluded as they were out of the scope of the framework.

Validity and Reliability of the Research Data

In order to ensure the validity and the reliability of the scale data, the diversification of both researchers and data were achieved. In this vein, the scale data were encoded by two specialized researchers in tandem with the main researcher and the codes were then found valid. The validity of the codes was calculated by the correspondence rate of Miles & Huberman (1994). The validity rate was found 86 percent among the researchers of the research. In the formula of Miles & Huberman (1994), an analysis is reliable if the validity rate between any two coding is above 80 percent. In this vein, it was believed that the analysis was reliable. The scale data were also supported by the secondary data to ensure the data diversification in the research. Besides, it was explained how the research data were collected, how the implementation process was performed and how the data analysis was made in detail. By giving a place to the direct quotations from the interviews and the video recordings, it was aimed to ensure the data validity and reliability.

Results of Research

The results of the research were classified upon the aspects of the nature of scientific inquiry.

Results about the "Scientific Questions Guide Investigations"

The views of the teacher candidates about this aspect were obtained by assessing their answers to the 1-6th questions. However, the findings from the 6-th question were not able to provide adequate information about the aspect. Therefore, only findings from the 1-st question were included in this section. "What types of activities do scientists do to learn about the natural world?" was asked of the teacher candidates in the aforementioned question. The results are given below in Table 2.

Table 2. Results about the guidance of questions to scientific investigations.

Pre	F	Post	F
Experiment	13	Experiment	19
Observation	8	Observation	18
Data collection	6	Data collection	6
Examination	6	Using imagination	4
Research	5	Research	3
Lab work	2		
Hypothesis	2		

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As seen in Table 2, the teacher candidates believed scientists usually fulfil their scientific investigations by making experiments and observations both in the pre-test and the post-test. They also believed that some different investigations were also fulfilled in the process. In this vein, it was seen that the teacher candidates believed different methods were used in the scientific investigations, but they did not make any explanation about the guidance of scientific questions to the investigations. Some of the exemplary quotations, which reflect the answer in a better way, are given below:

S33: Scientists make various experiments and observations. They try to reach a conclusion by collecting data about what they are investigating. (Pre-test)
S19: Scientists make observations and controlled experiments. They make projections and they use their imagination. They use trial and error method. (Post-test)

Teacher candidates' explanations during the class discussions were given in the following quotations for triangulation:

R: What did the scientists do to explain the results of their works here?
S7: Scientists reach their conclusions and perform experiments.
R: Do scientists make experiments during each process of their works? Is it possible to come to a conclusion without making an experiment?
S12: They also make observations.
S16: They make qualitative observations without making experiments.
R: How is a proposed theory accepted?
S13: Scientists prove it by making experiments.
S5: Scientists need to prove their proposed theories by making experiments. They must make them sense. If their theories make sense, they are supported by others. If not, they are rejected.
S4: Scientists make observations, experiments and researches.
R: Your friend just asked the same question that was asked by scientists centuries ago. Your friend questioned whether there is the smallest constituent of a matter. From this point, can you explain how the scientific investigations start?
S7: Curiosity is a must for starting a scientific investigation. There must be question marks about something and this point needs to follow asking the related questions.
S1: There must be a problem at the beginning. Then the related data need to be collected and a temporary answer needs to be produced upon the observations. Then these answers need to turn to a theory after a series of experiments.

As seen in the quotations above, the teacher candidates said that experiments and observations are the key in enabling a proposed theory to be accepted or an idea to be explained during the classroom discussions. It was, however, seen the teacher candidates told scientific questions must guide investigations in another classroom discussion. Although this result is positive, similar views were not shared by the majority. The findings of the research showed that the teacher candidates believed different methods were used in the scientific investigations, but they did not make any explanation about the guidance of scientific questions to the investigations.

Results about the Multiple Methods of Scientific Investigation

The teacher candidates' views about this aspect were obtained after their answers to the 1-3-4th questions. However, the findings from the 3-rd question were not able to provide adequate information about the aspect. Therefore, the findings from the other questions were included in this section. "Do you agree that to do good science, scientists must follow the scientific method?" was asked of the teacher candidates in the aforementioned question. The findings are given below in Table 3.

Table 3. Results about the multiple methods of scientific investigation.

Pre		Post			
Yes because...	F	Yes because...	F	No because...	F
Scientists do not want to come to a wrong conclusion	8	Scientists want to reach the exact knowledge	5	Different sciences require different methods	6
Science is universal	4	Scientific investigations are made in a specific order	4	Reasonable investigations enable scientists to come to a conclusion	1
Any step constitutes the basis to the following steps	4	Any step constitutes the basis to the following steps	3		
		Science is universal	2		

As seen in Table 3, the teacher candidates usually believed scientists should adopt a scientific method during the pre-test and the post-test. The teacher candidates explained why by saying that any step constitutes the basis for the next steps, preventing scientists to reach wrong conclusions. They added that science is universal. Some teacher candidates, however, expressed different views in the post-test and they said that there might not be specific scientific methods for scientists to follow as different science fields may require different methods. Some of the exemplary quotations, which reflect the answer in a better way, are given below:

S53: A scientist makes experiments, investigations and observations to understand the structure of the nature and s/he needs to do them in a systematic and orderly manner. A characteristic of a scientist should be doing science in an orderly and systematic manner. Before building a hypothesis, it is no meaning to make experiments or to collect data, as s/he needs to follow the scientific method to turn the hypothesis to a theory. (Pre-test)
S1: Scientists make their investigations upon the data they obtained by making a series of experiments and observations. In scientific endeavours, experiments play a big role. Experiments constitute an important step on the road to reaching exact conclusion about a problem. Scientists need to combine all these steps in a systematic manner. (Post-test)

Teacher candidates' views about the topic were also detected in the classroom discussions. The related quotations are given below:

R: How is a scientific investigation made?
S12: When making a scientific investigation, a hypothesis is built and experimental work starts. We have learned something called "scientific processes." The steps envisioned in scientific processes are followed. In my opinion, the accuracy of the obtained data cannot be believed without following each of these steps.
S11: A scientific investigation is made step by step. These steps are followed in a systematic manner.
S3: The first step should be to have a look at the obtained data and proofs, I believe. Are the hypotheses, data and proofs the same? If they are the same, the journey starts from the hypothesis to the theory step by step.
S7: There are the steps that take us to the theory. First, you build a hypothesis and then start to collect data. You examine whether the hypothesis is accurate.

Their views about the topic were also unleashed when the following question was asked during the interview sessions:

R: Do all scientists use the same method?
S6: Scientists can try different ways to reach accurate conclusions. They find new conclusions by changing qualitative and quantitative things. As the science constantly changes and is not exact, scientists always want to renew and change themselves. Therefore, there is not only one method.
S3: I do not think so. There are different methods. The scientific methods do not change, but scientists make different things to differentiate themselves from others. The point for them is to examine whether their conclusion is accurate or not at the end. The target is the same. There is only one right thing.
S12: It may change. The ways, which scientists use, may be different from each other.

S5: There are various steps that we use when examining different things. We need to follow these steps. Otherwise, we reach wrong conclusions.
S17: I believe we cannot change the scientific method. Scientists, however, may use different methods.
S8: No, they actually do not use the same method. While one scientist starts from one point, another starts from somewhere else.
S14: Yes, as scientists need to use the same method to reach systematic knowledge.

As seen in the quotations, the teacher candidates made different explanations at the classroom discussions and the interview questions. In this vein, it was seen that some of the teacher candidates emphasized that scientists can use different methods, although some others believed that there is a particular scientific method and several false conclusions are reached unless this method is followed.

In addition to the findings given above, in the first question, teacher candidates believed scientists usually fulfil their scientific investigations by making experiments and observations both in the pre-test and the post-test. They also believed that some different investigations were also fulfilled in the process. Similar findings were also detected in the classroom discussions. The related quotations are given below:

R: What must a scientist do to reach a conclusion? Which works must s/he do?
S3: S/he needs to collect data.
R: How does s/he collect the data? Through which activities does s/he collect?
S8: By making experiments.
S12: She can make observations as well.
S7: S/he may not obtain data by making only experiments. The data can be collected through observations as well. Several data can also be obtained upon the results of observations.
R: Can a scientist collect data only through experiments and observations?
S17: I believe that the results reached through all methods must be the same. I mean, these results can be proven through experiments and observations. Otherwise, everyone reaches different conclusions from each other.
S6: I believe that the experiment should not be taken as the main scientific activity. Scientists can make observations and surveys as well. They use the results of these activities as well.
S15: A theory is acceptable until the falseness of it is proven by experiments. If you are asking whether experiments are a must, as we had discussed earlier about various science branches, it is not possible to make experiments in every science branch. Scientists can reach conclusions by making observations as well.

As seen in the quotations, the teacher candidates emphasized the importance of experiments and observations in the classroom discussions. Besides, it was seen that the teacher candidates believed scientific investigations are made in orderly steps. In the post-implementation process, some of the teacher candidates said that there is not only one scientific method, but they could not develop adequate explanations about what these methods are.

Results about "the Multiple Purposes of Scientific Investigation"

The teacher candidates' views about this aspect were obtained after their answers to the 1-st question. This question was used to learn their views about a different aspect as well. In order to detect their views about this aspect, their answers were, however, re-analysed so as to meet the requirements of this aspect. "What types of activities do scientists do to learn about the natural world?" was asked to the teacher candidates in the aforementioned question. The obtained findings are given in Table 4.

Table 4. Results about the multiple purposes of scientific investigation.

Pre	F	Post	F
To learn the structure of the nature	11	To learn the structure of the nature	6
To satisfy the feeling of curiosity	3	To satisfy the feeling of curiosity	2
To find something good for humanity	3	To find something good for humanity	1
To make lab experiments	1		

As seen in Table 4, the teacher candidates generally said that the aim of scientific investigations is to learn the structure of the nature. Additionally, they mentioned the aim is to satisfy their curiosity and to find something good for humanity. Some of the exemplary quotations, which reflect the answer in a better way, are given below:

> S34: The aim of a scientist is to find and to develop something good for the good of the humanity by using the existing technologies. Scientists try to explore how the nature was formed and how it works along with other scientists from other disciplines. (Pre-test)
> S3: Scientists make investigations to learn the basics of the nature. (Post-test)
> Similar findings were also detected during the one-to-one interviews with the teacher candidates. The related quotations are given below:
> ***R: How do you define a scientist?***
> *S5: I define it as a person who wants to come to a conclusion. I believe scientists are the people who have curiosity and want to reach a conclusion by doing science.*
> *S9: A scientist makes investigations to satisfy her/his curiosity. I mean, s/he has curiosity and s/he is smart actually. Her/his intelligence works better than others.*
> ***R: What is science? What comes to your mind when somebody talks about science?***
> *S3: Science is the accumulation of the knowledge that is obtained through experiments and observations. Science is the act of obtaining a particular knowledge by means of several investigations and researches. Science is the act of offering benefits.*
> *S12: When somebody asks me about what science is, what comes to my mind is a group of people who are in white coats, making experiments, observations and inquiries.*

As seen in the quotations, the teacher candidates defined what science is for as several inquiries that are made for the good of humanity, to people's lives easier and to satisfy scientists' curiosity in their answers to the interview questions. In the research, the teacher candidates expressed more than one purpose when explaining the purposes of a scientific investigation, but they did not elaborate what these purposes are.

Results about "the Justification of the Scientific Knowledge"

The teacher candidates' views about this aspect were obtained after their answers to the 5-6th questions. However, the findings from the 6-th question were not able to provide adequate information about the aspect. Therefore, the findings from the 5-th question were included in this section. "When scientists are ready to report their results to other scientists, what kind of information do you think they need to include in their report in order to convince others that they have a good conclusion?" was asked to the teacher candidates in the aforementioned question. The obtained findings are given in Table 5.

Table 5. Results about the justification of the scientific knowledge.

Pre	F	Post	F
Experiments must be conducted	8	Experiments must be conducted	13
Knowledge must be proved	2	Observations must be made	3
Claim must be accepted by scientists	2	Evidence is needed	3
		Other scientists must find the same result	3

As seen in Table 5, the teacher candidates frequently said that experiments must be conducted to justify any scientific knowledge both in the pre-test and post-test. It was also seen that the teacher candidates mentioned the need for proving the knowledge and the acceptance of the claims by other scientists in the pre-test and they underlined the need for the results to be reached by other scientists as well in the post-test. Some of the exemplary quotations, which reflect the answer in a better way, are given below:

> S34: If a scientist reaches knowledge upon her/his experiments, s/he must prove it to others. (Pre-test)
> S15: Competent scientists need to agree the accuracy of the knowledge. (Post-test)

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Similar findings were also detected in the classroom discussions. The related quotations are given below:

R: What should scientists do to prove the accuracy of a knowledge?
S1: Scientists need to use the findings of their experiments or make new experiments and observations.
S17: Rationality speaks. If other scientists accept the knowledge as accurate, this knowledge is accepted by all.
S5: More is needed than making experiments. Scientists can come to a conclusion by using their observation data or research results as well.
S9: A scientist defines a hypothesis and makes several experiments to prove it. S/he makes further experiments to reach a more accurate conclusion.
S16: I believe, the point is that everyone must reach the same result. I mean, a scientist must support her/his hypotheses by making experiments. Otherwise, different results are reached by different people.
R: Why is Rutherford's atom model not accepted by other scientists? How do you explain why?
S8: Maybe he did not collect enough data or make enough experiments.
R: What do you refer by saying "enough"?
S12: Other scientists need to make experiments about the topic. And, different conclusions must be reached about the nature of the atom.
S2: The same experiments can be made with other scientists. They all make investigations and they decide whether the model is accurate or not.
S15: No. I believe they must make a common decision and all of them must agree on it.
S4: Other scientists make the same experiments with Rutherford. If they reach the same conclusion, they prove the model is accurate.

As seen in the quotations, the teacher candidates referred to mainly experiments and observations during the discussion session. They also mentioned that other scientists must back the data as well. It was seen that the teacher candidates usually said the scientists must make experiments to verify any knowledge both in the pre-implementation and in the post-implementation periods.

Results about "the Recognition and Handling of Anomalous Data"

The teacher candidates' views about this aspect were obtained after their answers to the 7-th question. The following question is "Scientists sometimes encounter inconsistent findings (anomalous information). What do you think scientists do when they find an anomaly?" The obtained findings are given in Table 6.

Table 6. Results on recognition and handling anomalous data.

Pre	F	Post	F
They change their hypothesis	6	They collect new data	9
They search for different data	5	They change their hypothesis	6
They try to figure out where they make a mistake	2	They make the experiment again	6
They initiate a new inquiry	2		

As seen in the Table 6 findings obtained in the pre-test and the post-test, the teacher candidates said that when scientists face anomalous and conflicting data, they change their hypothesis and they search for new data in the pre-test, and the candidates said that scientists change their hypothesis, collect new data and make their experiments again in the post-test. Some of the exemplary quotations, which reflect the answer in a better way, are given below:

S33: When a scientist faces an anomalous data, s/he can restart the data collection process. S/he might have made a mistake when collecting the data. (Pre-test)
S10: Scientists can change their hypothesis. Or they keep their expectations the same, but change the method. (Post-test)

The teacher candidates made similar views in the classroom discussions. The quotations are given below:

> ***R: Imagine scientists or you make an experiment. What do you do when the results are not parallel to your expectations?***
> *S3: First of all, I check my data out again to see whether I made a mistake or not. If I did not, I build a different experiment scheme. I mean, I try again and I collect new data. Then, I compare these data to the first data and find the mistake.*
> *S16: I suppose there is a mistake I made at the very beginning. I change my hypothesis and I collect new data.*
> *S8: If the scientist's work is conflicting with her/his expectations, other scientists should make experiments to check the accuracy of her/his data out. Other scientists may reach different results.*
> *S12: The simplest way is to make the experiment again.*

As seen in the quotations, the teacher candidates believed that scientists should make their experiments again, change their hypothesis and enable other scientists to check their data out when their data are conflicting with their expectations. It was seen that the teacher candidates expressed the same views about the aspect in the pre-test and post-test.

Results about "the Distinctions between Data and Evidence"

The teacher candidates' views about this aspect were obtained from their answers to the 2-nd question. The following question is A. What does the word "data" mean in science? B.Is "data" the same or different from "evidence"? However, the findings from the Item B were not able to provide adequate information about the aspect. Therefore, the findings from the Item A were included in this section. The obtained findings are given in Table 7.

Table 7. Results about the distinction between data and evidence.

Data				Evidence			
Pre	F	Post	F	Pre	F	Post	F
Knowledge	8	Knowledge	7	Verified knowledge	7	Verified knowledge	5
Unverified knowledge	5	Post-experiment knowledge	5	Knowledge	3	Results upon data	4
Changeable knowledge	3	Post-observation knowledge	4	Post-inquiry result	2	Data to be used to verify	3
		Proven knowledge	3			Post-experiment knowledge	2
		Pre-experiment knowledge	2				

As Table 7 was examined, it was seen that the teacher candidates mainly focused on the expressions of "knowledge" when explaining what data is and what evidence is. There were, however, some differences in the teacher candidates' use of this term when referring to data and evidence. While the teacher candidates defined what a data is as "the unverified and changeable knowledge" in the pre-test, they defined it as "the proven knowledge that is reached by experiments and observations" in the post-test. The teacher candidates frequently defined what an evidence is as "the verified knowledge" both in the pre-test and the post-test. They also defined it as "the post-inquiry result" in the pre-test and as the data result, the data to be used for verification and the post-experiment knowledge in the post-test. Some of the exemplary quotations, which reflect the answer in a better way, are given below:

> *S62: The data is accurate or inaccurate knowledge, which is learned about anything. The evidence is the proven versions of the learned knowledge. (Pre-test)*
> *S1: Data are the facts, which are reached by experiments and observations. Evidences are frozen facts. (Post-test).*

As it is seen, the teacher candidates describe data and evidence as different concepts. It was also seen that some of the teacher candidates changed their descriptions of the evidence in the post-test, making more accurate descriptions.

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Results about "the Community of Practice"

The teacher candidates' views about this aspect were obtained after their answers to the 6th question. The following question is (a) If several scientists, working independently, ask the *same question* and follow the *same procedures* to collect data, will they necessarily come to the *same conclusions*? Why or why not. (b) If several scientists, working independently, ask the *same question* and follow *different procedures* to collect data, will they necessarily come to the same conclusions? Why or why not. (c)Does your response to (a) change if the scientists are *working together*? Explain. (d) Does your response to (b) change if the scientists are *working together*? Explain. The obtained findings are given in Table 8 and Table 9.

Table 8. Results about the community of practice (a).

Pre				Post			
Yes because…	F	No because…	F	Yes because …	F	No because…	F
Yes	4	Thoughts and comments are different	5	Yes	2	Subjectivity matters	16
There is only one answer of any question	1	Personal skills are different	2			People have different imaginations	7
						People have different social circles	2
Findings about the Community of Practice (b)							
Yes	6	No	2	Subjective ideas affect the conclusions	7	No	3
Working together affects people's ideas	2	Ideas might be different	3	They might be affected from each other's ideas	6	It becomes more likely for them to reach a similar conclusion	2
The topic is the same	2	Discussions may occur	1				
The method is the same	1						
Timing and space is shared	1						

As seen in Table 8, the teacher candidates frequently believed scientists who use the same method cannot reach the same conclusion both in the pre-test and the post-test. While the teacher candidates explained why this is so with the "difference in ideas, comments and personal skills of the scientists" in the pre-test, they made explanations with the differences in "subjectivity, imagination powers and social circles" in the post-test. A majority of the teacher candidates said that scientists might change their minds if they work together. While the teacher candidates explained why this is so by saying that "the collective work affects the ideas, and the topic, the method, the space and the time are the same" in the pre-test, they made explanations by saying that "the scientists affect each other's ideas and the subjectivity matters" in the post-test. The obtained data from the questions of (c) and (d) are given in Table 9.

Table 9. Results about the community of practice (c).

Pre				Post			
Yes because...	F	No because…	F	Yes because…	F	No because…	F
Yes	9	No	4	Yes	2	No	3
		The method is different	2			The method is different	7
		Scientists have different perspectives	1			Subjectivity matters	7
Findings about the Community of Practice (d)							
Yes	1	No	4	Yes	1	No	6
The ideas are exchanged	1	The method is different	5	They reach the same conclusion	2	Subjectivity matters	4

	Pre		Post			
	The problem is the same	1	They affect each other's thoughts	2	The method is different	2
	There is no exact finding	1				

As seen in Table 9, the teacher candidates believed that scientists will reach the same conclusions in the pre-test. There were, however, teacher candidates who did not think so. It was seen that teacher candidates who said, "Yes" to the question in the pre-test did not make an explanation why, but teacher candidates who said "no" emphasized the differences in "the method and the perspectives." A majority of the teacher candidates said "no" to the questions in the post-test. They explained why they believed so by referring to "the use of different methods and the impact of the subjectivity." The teacher candidates noted that the scientists do not change their minds when they work together both in the pre-test and the post-test. They explained why they believed so by referring to "the difference in the method" in the pre-test, although they made an explanation upon "the impact of the subjectivity and the difference in methods" in the post-test.

Some of the exemplary quotations, which reflect the answer in a better way, are given below:

S7: They might not reach the same conclusion when they work separately. They do not have to...I do not change my mind when they work together as then they would put their rights and wrongs on the table to reach a common ground. They might also not be reaching the same conclusion when they use different methods...I might think different when they work together as we can go to the same place via different routes. (Pre-test)
S15: When they work separately, they might be reaching the same conclusion as subjectivity matters...I believe so even if they work together as their ideas might be different from each other. This may lead to the attaining different conclusions. They also might reach different conclusions when they use different methods from each other as their methods are different from each other and they have their own ideas...I do not change my mind even if they work together as their ideas and methods are different from each other. (Post-test)

The teacher candidates made similar views in the classroom discussions. The quotations are given below:

R: Do scientists reach the same results when they work together by using the same method?
S14: I think they need to discuss and to say what their faults are to each other. They should work together and criticize each other not to affect each other or to reach a common conclusion. They can thus reach different conclusions.
S6: If they work together, they need to learn something from each other. It is not necessary for them to work together unless they affect each other or share their data with each other. They do not have to come to a common conclusion. They should however make some joint investigations. They might reach different conclusions by working together. I believe they must be affecting each other's thoughts when they work together.
S12: They create their own hypotheses on the same experiment data. They might create different hypotheses from each other.

As seen in the quotations, the teacher candidates believed that the scientists might affect each other when they work together and they might then change their minds. The candidates said that the scientists might reach the same conclusion or not when they use different methods. When the views about the community of practice aspect were assessed, it was seen that the teacher candidates believed the scientific investigations are made in a particular community and can be affected from the structure of the society. They also believed that the investigations can be affected from the people's subjective thoughts.

Discussion

The research aims to find out the views of science teacher candidates about the nature of scientific inquiry and the impact of the teaching by history of science upon these views. The findings of the research showed that the science teacher candidates' views about the nature of scientific inquiries were parallel to each other in the pre-implementation and the post-implementation processes, but some of their thoughts changed after the implementation process. This shows that the teaching by using history of science is partially effective, but there is a need to make some revisions in the teaching scheme.

The guidance of the scientific questions to the investigations refers that the scientists start their investigations by defining a scientific question before building a hypothesis and they can use different method in this process (Schwartz, Lederman & Lederman, 2008). When the results about "scientific questions guide investigations" are assessed, the data of the research showed that the teacher candidates could not make adequate explanations about the guidance of the scientific questions to the investigations both before and after the implementation process. The teacher candidates frequently said the scientists make their investigations by means of "experiments and observations" in their answers to the related question. This showed that the teacher candidates' views about this aspect were "weak" both in the pre-test and the post-test.

Despite these results about this aspect in the research's interview session, it was seen that the teacher candidates made partially adequate comments about the topic during the classroom discussions. This showed that even some of the teacher candidates have adequate understandings. As the teacher candidates did not, however, show the same performance when answering the scale questions, it was believed that they had not given wider opportunities to make direct investigations about the topic during the teaching activities in the classroom. Hughes, Molyneaux & Dixon (2012), however, said the views about the scientific investigations might not be developed even if any scientific investigation practices are made in the classroom. This indicates that highly challenging and long processes are needed to enable students to get the views about the scientific inquiries, as is the case for the nature of science. Nevertheless, it is believed that it is possible to enable students to get different skills of how to prepare research questions, how to collect data or how to reach conclusions by bringing them into a scientific investigation. Thus, in the research based on direct researches in the laboratory by Northcutt & Schwartz (2013) with a number of teacher candidates, it was seen that the candidates said that the scientific investigations start with the scientific questions.

There are multiple methods that can be used by scientists to find the answers to their questions. There is not only one scientific method for scientists to reach the accurate knowledge (Schwartz, Lederman & Lederman, 2008). The results about "multiple methods of scientific investigation" aspect showed that the teacher candidates focused on the existence of "only one" scientific method before the implementation process. This showed that the teacher candidates had "weaker" understandings about the topic in the pre-implementation process. Similar findings were reached by Bell, Blair, Crawford & Lederman (2003). The results of the two studies revealed a general view about the scientific method. Despite this view expressed by people of different levels and ages, as McComas, Clough & Almazroa (2000) mentioned, there is not only one way of making science. The data obtained in the post-implementation period of the research showed that some of the teacher candidates, but not many, expressed the need for the multiple methods, showing there is a change, even tiny, in their views about the aspect. In this vein, it is believed that the implemented teaching led some positive results in regard to the aspect.

In the justification of the scientific knowledge, any evidence relevant to the claims must be underlined and the regarding scientific principles, models and theories must be used accordingly. Coming to a conclusion about any problem includes the accumulation of evidences to justify the claims (Schwartz, Lederman & Lederman, 2008). In the research, it was seen that the teacher candidates usually said the scientists must make experiments to verify any knowledge both in the pre-implementation and in the post-implementation periods. In this context, it can be said that the teacher candidates have a "weaker" view about the "justification of scientific knowledge" aspect. Being underlined in the literature frequently, this view also indicated a misconception (Wenning, 2006). McComas (2000) said that making experiments is the most practical tool in the natural sciences, but is not the only way, and many scientists also use non-experimental techniques to progress their knowledge. It is believed that the research result might be connected to the educational background of the teacher candidates. Besides, the teacher candidates focused on the lives, inquiries and experiments of various scientists from the field of chemistry during the implementation period. It is believed that this might lead to the resistance to change in the teacher candidates' views about the topic. In this vein, the existing misconception seen in the views of the majority of the teacher candidates showed that the implemented teaching had offered effective results about the aspect.

Scientific investigations are made in a particular community and scientists conclude their scientific inquiries by asking questions about the inquiries of other scientists. Necessary experiments and procedures are gained along with this community on the road to producing and accepting any scientific knowledge (Schwartz, Lederman & Lederman, 2008). The results about the "community of practice" aspect showed that the teacher candidates said that the scientists do not reach the same conclusions when they start with the same question and use the same methods to collect data, and the candidates associated their views with the importance of subjectivity both in the pre-test and the post-test. The teacher candidates said that when the scientists use different scientific methods, these scientists can reach the same conclusion, but they did not elaborate why they believed so in the pre-test. In the post-test, the candidates said that the scientists cannot reach the same conclusion as they use different methods and they have personal differences. Additionally, the teacher candidates said that the scientists can affect each other's ideas in their answers to the questions.

When the views about this aspect were assessed, it was seen that the teacher candidates believed the scientific inquiries are made in a particular community and can be affected from the structure of the society. They also believed that the investigations can be affected from the people's subjective thoughts. In this vein, the teacher candidates' views about the aspect are close to the "informed" level both in the pre-test and the post-test. Henceforth, scientific inquiries are affected from the values of the society in which they are made (Schwartz, Lederman & Lederman, 2008). Scientists work with research groups in a particular group. Many scientific problems have a so complex structure that cannot be solved by one person (McComas, 2000). The research data showed that the teacher candidates have a modern perspective about the social impact upon the scientific inquiries as seen in their answers in the pre-test and the post-test.

Scientists define problems from many different sources and these sources serve to a number of different purposes. The problems may be defined by curiosity, social interaction, availability of the topic and many other sources. Scientific investigations may help to resolve any social issue, to make a contribution to the nature of the humanity or to understand the world (Schwartz, Lederman & Lederman, 2008). The results about "multiple purposes of scientific investigation" aspect showed that, the teacher candidates expressed more than one purpose when explaining the purposes of a scientific investigation, but they did not elaborate what these purposes are. In this context, it can be said that the teacher candidates' views about the aspect are at the "informed" level both in the pre-test and the post-test.

Scientific investigations are supported with knowledge and theories in line with expectation of scientists. Encountering with any data contradicting with the expectations constitutes a critical basis of the scientific investigation process. Anomalous data pave the way for new questions and new inquiries (Schwartz, Lederman & Lederman, 2008). When the views about the "justification of the scientific knowledge" aspect assessed the teacher candidates said that the scientists change their hypotheses, search for new data and make their experiments again when they face any conflicting data both in the pre-test and the post-test. It was seen that the teacher candidates expressed the same views about the aspect in the pre-test and post-test, and that their perspectives can be classified in the "informed" level in the both tests.

The data and the evidence serve different aims and they come from different sources. The data refer to the observations of a scientist during the inquiry process. The evidence is a product, which is obtained through the data analyses and assessments (Schwartz, Lederman & Lederman, 2008). The teacher candidates describe data and evidence as different concepts. While the candidates' explanations about these concepts centred upon the theme of knowledge, they made different descriptions about attaining the knowledge. It was also seen that some of the teacher candidates changed their descriptions of the evidence in the post-test, making more accurate descriptions. In this vein, the teacher candidates' views about the aspect are between the levels of "informed" and "sophisticated" in the pre-test, but their views are much closer to the level of "sophisticated" in the post-test.

Conclusions

The aim of the research is to determine the views of the science teacher candidates about the nature of scientific inquiry before and after a history of science - based teaching process. When the results of the research are assessed, it can be said that the teacher candidates' views about the guidance of the scientific questions to the scientific investigations, the multiple purposes of the scientific investigations and the justification of the scientific knowledge were "weak" in the pre-test, and their views about the remaining aspects were at the level of "informed." The teacher candidates could not express "sophisticated" views about any aspect. After the implementation process, it was seen that the teacher candidates' views about the method diversity and the distinctions between the data and the evidence improved, but there was no difference in their views about other aspects. This result shows that the teacher candidates still expressed "weaker" views about the justification of the scientific knowledge in the post-implementation period.

In the research, a teaching where the history of science was in the focus and the aspects of the nature of

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scientific research were discussed in the process was realized in the light of different events and experiences of real life and the idea that accurate teaching of science history would contribute to the development of teacher candidates' views on the research process. However, the result of the research shows that the teaching with only the science history does not make the sufficient influence on the understanding of teacher candidates about the nature of scientific research.

The results indicate that the specially designed and planned teaching processes are needed to teach the nature of scientific inquiries. The results also show that the views about the nature of scientific inquiries cannot be taught as a secondary product and this teaching must be made directly.

According to Hughes, Molyneaux & Dixon (2012), teachers may not be developing adequate understanding about the nature of scientific inquiries even if they make inquiries. In this regard, it is apparent that new teaching designs, which could allow both students and teacher candidates to develop multi-skills and to apply different practices, are needed. The focus in education is to add skills more than one rather than adding one single skill. In this respect, future researchers are advised to plan research techniques which would be applied in a parallel way with science history and allow participants to have direct experiences and to make students develop multi-skills at the same time with using their knowledge of science-technology-engineering-mathematic in this process.

Besides this upon the results of the research, it is suggested to offer curricula through which teacher candidates can discuss the nature of scientific inquiries and to create environments in which teachers/teacher candidates can make inquiries directly in the research-based classes. In addition to purely teaching by history of science in teaching the nature of scientific inquiries, it is also suggested to add different factors which will enable students to be more active and different activities which will give the chance to them experience the learning process directly, such as history of science-based dramas, scenarios and movies. In the history of science -based activities, the emphases on what scientists did and the inferences to various scientific inquiries are believed to make a positive contribution to developing the views about the nature of scientific inquiries.

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