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# The effect of learning the history of physics on the scientific epistemological beliefs of pre-service teachers

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ABSTRACT: This study examined the effect of learning the history of physics on the epistemological beliefs of pre-service physics teachers. The research was conducted with 25 pre-service physics teachers using a single-group pre-test/post-test experimental model. The quantitative data of the research were collected using the Turkish version of the Scientific Epistemological Views Questionnaire (SEVQ). The qualitative data of the research were collected through interview questions that were suitably prepared for the sub-domains of the SEVQ. In addition, in the post-interview, the students were asked what they had gained from the course. The quantitative analysis of the research was performed by using the K-S Test for Normality and Wilcoxon Signed Rank Test. The data obtained from the interviews were evaluated according to the descriptive analysis method and the data results were converted into quantitative data by using an interview analysis rubric. It was seen from the evaluation of data prior to and following a period of instruction that learning about the history of physics positively contributed to the views of pre-service teachers regarding the interaction and communication of scientists in the process of developing scientific knowledge. All of the results obtained have been interpreted in detail and presented in the present work.

KEY WORDS: History of physics, epistemological beliefs, pre-service teachers, teacher education

## INTRODUCTION

As the influence on the structure and practices of education shifted from a behavioral approach to a constructivist approach, the elements of teaching and instruction took on their respective roles in the change. Teachers as the implementers of change are an important element in this context. To the degree that teachers internalize and implement the changes that have been made, their contribution to the success of the system will be that much greater (Gömleksiz, 2007). In Turkey, starting from 2004/5, science and physics curriculums have been revised in line with a constructivist approach. Studies carried out after the adoption of the new regulations have shown that teachers show a positive attitude toward the change

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(Balım, Kesercioğlu, İnel & Evrekli, 2009; Çınar, Teyfur & Teyfur, 2006; Ocak, 2010). However, since most teachers were themselves educated in traditional patterns of instruction, they find it a challenge to develop and apply their thoughts in the direction of constructivist learning and teaching (Brooks & Brooks, 1993; Karacaoğlu & Acar, 2010; Trumbull & Slack, 1991; Tsai, 2002). The new system has brought with it certain innovations in the area of teacher education. In 2011, the Ministry of National Education General Directorate of Teacher Training and Education set forth specialized competencies in all fields of teaching, coupling this with performance indicators that would be used to evaluate these competencies. Among the competencies defined for physics teachers is physics literacy, which encompasses within the scope of its sub-competencies, attitudes and values that include problem-solving skills and laboratory use, physics technology, interaction with the community and the environment, informatics and interactive skills, and professional development (MEB, 2011). The values embraced in this context constitute the knowledge teacher candidates have about the nature of science and their epistemological beliefs in the context of the field of science/physics. The development of pre-service teachers' thoughts and beliefs is therefore important in terms of formulating national teacher training policies.

Studies emphasize that knowledge of individuals about the nature of science are a part of their own scientific epistemological beliefs and the (Lederman, 1992; Lederman, Abd-el-Khalick, Bell & Schwartz, 2002; Marra & Palmer, 2005).

In their compilation of the literature, Tabak and Weinstock (2010) have analyzed scientific epistemological beliefs in the studies in three main categories relating to learning science, the nature of scientific knowledge, and the structure of science. These beliefs are important in teacher education because teacher formation depends upon the epistemological beliefs teachers have about learning and the teaching environment (Brownlee, 2004; Flores, 2001; Hammer, Elby, Scherr & Redish, 2005; Hashweh, 1996; Hofer, 2004; Knoblock & Hoop, 2005; Ioannis, 2005; Lederman, 1992; Schraw & Olafson, 2002; Tsai, 2007; Topcu, 2011). For instance,

Schraw and Olafson (2002) classified teachers' epistemological beliefs as realist, contextualist and relativist. Teachers with a realist's worldview transfer knowledge and teach with a teacher-centered approach. Teachers with a contextualist perspective only focus on structuring knowledge and applications on the basis of the subject content that is being learned. Relativist teachers allow students to think and learn independently and arrange the class environment using constructivist applications.

Hashweh (1996) has classified teachers according to their epistemological views, positioning them as constructivist or empiricist. Study results have shown that constructivist teachers are more effective than empiricist teachers in defining and determining the alternative conceptions that students may have. In addition, constructivist teachers are able to use more methods and more effective methods and strategies to ensure conceptual development in their students, compared to empiricist teachers.

Tsai (2007) has classified teachers according to their epistemological views as constructivist-oriented or positivist-aligned. According to this study, constructivist-oriented teachers prepare more constructivist-based learning environments compared to positivist-aligned teachers. Constructivist teachers allocate more time to students' research and their interaction in discussions, thereby focusing on their comprehension of scientific concepts and applications. Positivist-aligned teachers however adopt a teacher-centered teaching model and keep students in the position of being passive receivers of knowledge, engaging students in the classroom only in problem-solving from examples in the textbook and focusing on the numeric results of students' tests.

Topcu (2011) has reported that teachers with constructivist-based epistemological beliefs, contrary to teachers with traditional realist-based epistemological beliefs, place more attention on student discussion, interaction, problem-solving and other similar activities.

Knobloch and Hoop (2005) have shown that behaviorist pre-service teachers prefer and feel much better prepared with more detailed daily plans instead of working with less detailed unit plans. Constructivist pre-service teachers, however, express the opinion that detailed daily plans hamper their creativity and instead show an interest in unit plans that focus on content.

Under the circumstances, then, it is important that thoughts are developed in the desired direction.

According to what Knobloch and Hoop (2005) have referred to in Bandura's work (1986), individuals' beliefs are influenced by their environments, their perceptions and their behavior. As the level of training in the specific field of teaching increases, the epistemological beliefs relating to that field change and become more sophisticated with time (Brownlee, 2004; Brownlee, Purdie & Boulton-Lewis, 2001; Çoban, Ateş & Şengören, 2011; Kienhues, Bromme & Stahl, 2008; Ng, Nicholas & Williams, 2010; Özgün-Koca & Şen, 2006; Tsai, 2006,). At this point, the approach, experience and practices that contribute to achieving the development that will bring about the needed change during the education received are important. A study of the literature on the development of the epistemological beliefs of teachers and pre-service teachers does not reveal a clear model as to a definitive and valid mechanism that is effective in this change. The approaches and applications used in the studies either focus directly on epistemological beliefs and the changes seen in these, or on the indirect development of beliefs through adjustments made in the learning and teaching environment (Brownlee, 2004).

Studies that concentrate directly on the development of beliefs emphasize the importance of contact, discussion and regular journal writing in encouraging individuals to be aware of their own epistemological beliefs about the subjects touched upon in the learning process (Brownlee, 2004; Brownlee et al., 2001; Stacey, Brownlee, Thorpe & Reeves, 2005). These studies have achieved the development of epistemological beliefs by directly making pre-service teachers aware of their beliefs about a particular topic and leading them to reconstruct their beliefs. It is also reported, however, that attempts to have individuals reconstruct their personal beliefs by associating a topic with related theories are not always successful in areas of science (Brownlee, 2004). This is because constructing knowledge in science is based not on personal views but on different resources such as thought, deduction and experimentation (Brownlee, 2004; Lederman, 1992).

Studies that have aimed to achieve a development of beliefs through indirect means have examined the effect of methods and techniques based on a constructivist approach on the development of beliefs related to the subject being taught. It has been set forth in one study (Tsai, 2006) that instruction that includes committee work, concept mapping, drawing up Venn diagrams, classroom knowledge sharing, discussion and activities such as group presentations are successful in developing the views of science teachers and pre-service science teachers regarding the nature of science. Another study (Tsai, 2009) has used the method of online peer assessment with students in the preschool teaching branch. In this method, the students' preparations for science activities geared to preschoolers are discussed with and evaluated by their friends online. Students are able to reconstruct the activities in the light of these assessments. The result of this study showed that students improved their epistemological beliefs about science.

Other studies that have aimed to achieve belief development by indirect methods have examined the effects of domain-specific education in a particular field (teaching principles, methods and techniques, history of science and philosophy, etc.) on the development of domain-specific beliefs.

In studies about knowledge of different teaching fields, it has been shown that pre-service teachers who have been given training in the light of principles and applications with a constructivist approach and have studied educational psychology, learning theories, the basic elements of education, training and classroom settings, exhibit positive development in their epistemological beliefs regarding learning and teaching (Chai, Teo & Lee, 2009; Ng et al., 2010; Özgün-Koca & Şen, 2006).

Studies that focus on the development of teachers' epistemological beliefs specifically regarding the domains of science and physics, which is the foundation of the present research, base their work on two approaches that are in reality not too independent of each other--an implicit and an explicit approach (Abd-el-Khalick & Lederman, 2000a). Researchers have reported that an explicit approach that encourages sophisticated views is a better method to use to increase understanding about the nature of science. In studies with an implicit approach, the focus is on skills regarding the use of the scientific method and research activities based on instruction and science (Abd-el-Khalick & Lederman, 2000a). Structured experiments (Falk, 2000; Koponen, Mäntylä & Lavonen, 2004; Koponen & Mäntylä, 2006) to ensure the understanding of the nature and development of scientific knowledge and scientific methodology and the development of beliefs related to these may be cited as examples of this. Two studies have set forth that the method that they call "generative experimentality" has developed the epistemological beliefs of pre-service physics teachers (Koponen et al., 2004; Koponen & Mäntylä, 2006). Falk (2000) has stressed that the method of carrying out historical experiments helps pre-service physics teachers to better understand the nature of scientific knowledge, its development and scientific methodology. In studies carried out with an explicit approach, the focus in on instructional activities using the elements of science history, philosophy and the nature of science. With respect to the development of views and understanding about the nature of science, studies that contain teaching activities that encompass elements used in the history of science (Abd-el-Khalick & Lederman, 2000b), the history of chemistry (Lin & Chen, 2002) and the philosophy of chemistry (Erduran, Bravo & Naaman, 2007) may be given as examples. With their study, Abd-el Khalick et al. (2000b) have asserted that teaching the history of science contributes very little to students' thoughts about the nature of science. Because of this, the researchers state that no fundamental conclusion can be reached to the effect that teaching the history of science develops students' thoughts about the nature of science. Lin and Chen (2002) were able to show how history could be used to teach chemistry and reported that their study group of pre-service teachers exhibited a better performance in understanding the nature of science compared to pre-service teachers in the control group. In the study of Erduran et al. (2007), the conclusion was derived that teaching models that contained the philosophy of chemistry were effective in ensuring the development of teachers' epistemological beliefs about the subject being taught. The researchers at the same time emphasized that domain-specific applications and not general applications about the history of science were more effective in leading students to learn the targeted material. Thus, it may be said that the historical development of teaching and instruction should be assessed in domain-specific terms in physics as in the example of chemistry.

Seroglou and Koumaras (2001, as cited in Wandersee, 1985), have pointed out that a teacher with a knowledge of the history of physics would be able to compare students' current misconceptions with related misconceptions throughout the course of history and in so doing, be better equipped to help students eliminate such misconceptions. At this point, the history of physics will provide historical experiments and problems as well as teaching materials and other elements of instruction that will support the teaching of scientific methodologies deemed to be effective in students' cognitive development (Seroglou & Koumaras, 2001 as cited in Arons 1959, 1990; Brush, 1969; Chambers, 1989; Dunn, 1993; Sherratt, 1980; Spurgin, 1990).

The history of physics reveals the interaction between science, technology and culture and as such, dramatizing the development of physics in the classroom increases student interest in the course. This also ensures the construction of students' thoughts about science, scientists and scientific knowledge (Seroglou & Koumaras, 2001).

Teixeira, Greca and Freire (2012) have achieved access to 152 published studies in international journals about using the history of science and philosophy in science education by scanning the keywords, *science teaching*, *history of science*, *philosophy of science*, *nature of science*, *physics teaching*, and *physics education*. Of these 152 studies, only 11 directly concern the use of history and philosophy in physics education. No study examining the effects of learning about the historical development of physics on the epistemological beliefs of pre-service physics teachers has been noted in the tables of general definitions (pages 8 and 9) that the researchers have set up. Moreover, such a work could neither be found among the national and international publications that were scanned by the author of the present study. At this point, it is believed that a study of this kind, carried out specifically for physics, would make an important contribution to the field.

The present study, which was conducted to contribute to the training of physics teachers in line with the criteria set forth in the field of physics education and in national teacher education policies, aimed to determine whether learning about the historical development of certain basic topics in physics would have an impact on the scientific epistemological beliefs of physics pre-service teachers.

## METHOD

### *Sample and research model*

The sample consisted of 25 pre-service teachers enrolled in the physics teaching program who were taking a course on the Historical Development of Physics. If the sample in a study has been chosen from among individuals carrying suitable and specific characteristics that are needed in the study, this method of selection is called the criterion sampling method (Patton, 2002; pp. 230, 238). In this research, the criterion sampling method was used because the participants in the study were students who were taking the course on the subject of the research.

Because the sampling could not be selected in an unbiased manner and the development of the individuals was being examined in the experimental process in a single group, the research model was defined as a single-group pre-test/post-test quasi-experimental model.

The collection of the data and their evaluation were analyzed in the research both quantitatively and qualitatively. The qualitative data explain and verify the quantitative data. Because of this, an explanatory-confirmatory mixed design approach was adopted.

### *Data collection tools*

The quantitative data of the research were collected using the Scientific Epistemological Views Questionnaire (SEVQ), the original of which was developed by Tsai and Liu (2005) and adapted into Turkish by Uysal (2010).

The final version of the original developed by Tsai and Liu (2005) consists of 19 items. In the factor analysis, these items were collected in 5 sub-domains: "The role of social negotiation (SN)", "The Invented and Creative Nature of Science (IC)", "Theory-laden exploration (TL)", "Cultural Impacts (CU)", and "The changing and tentative feature of science knowledge (CT)". The Cronbach alpha coefficients for these factors were determined as .71, .60, .68, .71 and .60, respectively.

In the validity and reliability study conducted by Uysal (2010) to obtain the Turkish version of the scale, the reliability coefficient was found to be .72. The Cronbach alpha coefficients for the factors determined in the work of Tsai and Liu (2005) were found by Uysal (2010) to be .77, .75, .06, .14 and .47, respectively. Because of the very small reliability coefficients found for the sub-domains TL and CU, the items that comprised these two factors were removed from the Turkish version. Using the structural equation modeling technique for the remaining three factors, confirmatory factor analysis was carried out. In the proposed three-factor model, index values were determined as RMSEA=.04, SRMR=.02, GFI=.98 and AGFI=.97. Accordingly, the

Turkish scale was implemented and evaluated on the basis of the sub-domains SN, IC and CT and on the total of 13 items included in these domains.

**Table 1. Turkish SEVQ Domains and Items**

| Domains | Items |
|---|---|
| The role of social negotiation (SN) | 1, 6, 16, 10, 13, 9 |
| The invented and creative nature of science (IC) | 11, 2, 5, 17 |
| The changing and tentative feature of science knowledge (CT) | 3, 14, 18 |

The students responded to this 5-item Likert-type scale by marking their choice from answers that ranged from "I definitely don't agree", representing 1 point, to "I definitely agree", representing 5 points. The higher mean scores obtained from the domains show that the student has a constructivist view in that dimension, while low mean scores indicate an empiricist view.

The qualitative data of the research was collected through interview questions that were suitably prepared for the sub-domains of the SEVQ, as set forth in Tsai and Liu's (2005;pp 1625-1626) study. In addition, in the post-interview, the students were asked what they had gained from the course.

**Table 2. Interview Questions and Domains**

| Domains | Questions |
|---|---|
| The role of social negotiation (SN) | Q1. Do other scientists influence a scientist's research work?<br>Q2. Is science a process of individual exploration, mainly depending on personal efforts? How so?<br>Q3. How do scientists examine the research findings of others? |
| The invented and creative nature of science (IC) | Q1. Do scientists "discover" or "invent" scientific knowledge? Why?<br>Q2. How does creativity play a role in science? |
| The changing and tentative feature of science knowledge (CT) | Q1. After scientists have developed a theory, does the theory ever change?<br>Q2. Does the development of scientific knowledge involve a change of concepts? How? |

Both data collection instruments were implemented twice, first before the experimental process for pre-measurement and then for post-measurement after the process. At both stages, the scale was implemented first, and then the interviews were conducted.

### *Data analysis*

The pre- and post-measurement data obtained from the SEVQ were analyzed using the SPSS statistical program. Descriptive statistical methods were used to assess whether students held constructivist or empiricist views related to each domain. Because the number of subjects in the sample was less than 30, the K-S Test for Normality was applied to the data to decide on the statistical analysis method that would determine whether or not the views of the students had changed. It was found in the results of the K-S test that the total scores in the pre-measurement (D(25)=.123, P=.200) and in the post-measurement (D(25)=.123, P=.200) and the pre-measurement scores in the CT sub-domain (D(25)=.156, p=.118) were consistent with normal distribution; it was seen however that the pre-measurement scores in the SN and IC sub-domains (D(25)=.205, p=.008, D(25)=.208, p=.007, respectively) and the post-measurement scores in the SN, IC and CT sub-domains (D(25)=.239, p=.001, D(25)=.189, p=.021, D(25)=.226, p=.002, respectively) were not consistent with normal distribution. Because some of the measurements did not exhibit normal distribution, the differences between the pre- and post-measurements of the SEVQ data were analyzed using the Wilcoxon Signed Rank Test.

The face-to-face and semi-structured interviews held by the researcher for qualitative evaluation were recorded on a voice recorder to avoid the loss of data. The data obtained from the interviews were evaluated according to the descriptive analysis method. The goal in choosing the descriptive analysis method was to summarize and interpret the data according to the themes determined within the theoretical framework set up for the subject of the study (Yıldırım & Şimşek, 2005). The recorded voices of the students were transcribed by the researcher and converted into a written text. The transcribed text files were coded for each student as S1, S2, S3, ... S25 under the SN, IC and CT domains. Although the data were collected for qualitative evaluation, the data results were converted into quantitative data in order to determine to which degree the SEVQ supported the results. The rubric drawn up by the two analyzers on the basis of a joint decision was used at this stage. The details of the rubric that was used can be seen in Table 3. The scores obtained by the two analyzers according to the rubric but independently of each other were compared and the coefficient of concordance was found to be .83.

Following these procedures, it was seen that the totals obtained in the pre-interviews, the scores in SN, IC and CT ( D(25)=.343, p=,000, D(25)=.390, p=.000, D(25)=.457, p=.000, D(25)=.521, p=.000, respectively ) and the same scores obtained in the post-interview (D(25)=.325, p=,000, D(25)=.409, p=.000, D(25)=.521, p=.000, D(25)=.534, p=.000, respectively) were inconsistent with normal distribution. Because of this, the analysis of these scores was carried out using the Wilcoxon Signed Rank Test. Furthermore, sample sentences from the students' views and their thoughts on the course were added to the conclusion section.

**Table 3. Interview Analysis Rubric**

| |
|---|
| 0-No response |
| 1-Views are empiricist. They believe that scientists are not influenced by their environment or by other scientists. They believe that the success of a scientist depends upon individual effort. They believe that scientists' value judgments are shaped according to their own knowledge and beliefs. They believe that scientific knowledge and related theories and concepts will never change. They don't allow for imagination, creativity and luck in the gathering of scientific knowledge. They believe that scientific facts are based more on discovery rather than on findings. |
| 2- Views are constructivist. They believe that scientists can be influenced by their environment or by other scientists. They believe that the success of a scientist does not depend on individual effort but that the scientist will benefit from the contributions of other scientists and the environment. They believe that scientists' value judgments are not shaped according to their own knowledge and beliefs, but that the value judgments of other scientists are important. They believe that scientific knowledge and related theories and concepts can change at any time. They allow for imagination, creativity and luck in the gathering of scientific knowledge. They believe that scientific facts are based more on findings rather than discovery. |

***The process***

The course on the Historical Development of Physics is an elective that is studied in the first semester of the fourth year undergraduate curriculum in the five-year Physics Teaching program. There are two weekly course hours and a semester consists of 14 weeks. The content of the course encompasses the basic concepts of the historical development of the subjects of mechanics, electricity and magnetism, optics, thermodynamics, atomic and molecular physics, which the pre-service teachers will be teaching in their professional lives ahead. Instead of focusing directly on concepts, however, more time is spent in the course on learning about the life and times of the scientists mentioned in the history, and about Nobel physics prize winners, the general characteristics of their eras and the geography of which they are a part.

The pre-measurement on the SEVQ was taken in the first lesson of the first week. The participants were then informed about the content of the course and the references that would be used. Because the students were in their fourth year, they had already covered the basic subjects mentioned. They were accordingly familiar with the fundamental topics. The method that would be adopted in the course was decided upon together with the students. The decision was to use a method of research-based group work, group presentations and discussions. In this setting, the teacher is in a position of being both an advisor and a guide. The 25 students formed groups of five among themselves with the individuals of their choice for the five fundamental topics mentioned above. Appointments for interviews were set up with the students for the first week and preliminary interviews were completed.

Over the four weeks after the first week, the students carried out their research. In these four weeks, the students were required to inform the instructor of what they were doing and their plans, not only in class but also outside of class. The instructor evaluated the work of each group, making recommendations and providing feedback with guiding questions. In the remaining seven weeks, the groups presented their research topics to the class and various opportunities for discussion were provided. Following the presentations, the post-measurement for the SEVQ was carried out in the 13th week. Again, the final interviews were conducted with the students in this week. In the last and 14th week, the instructor presented information from the literature on the importance of history in physics education.

## RESULTS

### *Results of the SEVQ*

The total points a student could receive from the SEVQ scale were 13-65, and the possible scores that could be obtained from the SN, IC and CT sub-domains ranged between 6-30, 4-20 and 3-15, respectively. The higher scores indicated that the students had constructivist views, the lower scores meant that the students had empiricist views. Thus, the first objective was to define the values that would indicate what the students' views were in the pre- and post-measurements of the SEVQ. Descriptive statistical processes were used for this purpose. The results of these are presented in Table 4.

**Table 4. SEVQ Pre- and Post-measurement Score Data**

| Measurement | N | Total | | SN | | IC | | CT | |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Std. Dev. | Mean | Std. Dev. | Mean | Std. Dev. | Mean | Std. Dev. |
| Pre- | 25 | 50.76 | 5.27 | 23.68 | 2.84 | 16.4 | 3.08 | 10.68 | 1.31 |
| Post- | 25 | 51.64 | 3.96 | 23.84 | 3.33 | 16.92 | 2.1 | 10.88 | 1.42 |

A look into the students' pre- and post-measurement mean scores on the SEVQ scale shows that these are close to the upper boundary. Thus, it can be said the students' scientific epistemological beliefs in the dimensions evaluated were closer to a constructivist point of view.

An evaluation of the total score and sub-domain scores indicates that the scores in the post-measurement were higher than the scores in the pre-measurement. To understand whether the difference was a significant one, the pre- and post-measurement scores were compared using the Wilcoxon Signed Rank Test.

In the analysis, it was found that the difference between the pre- and post-measurement values in the total scores on the scale (T=91,5, p=.254, z=-1.141, r= -.228) and the scores in the sub-domains SN (T=103, p=.438, z=-.776, r= -.155), IC (T=77, p=.455, z=-.747, r= -.149), and CT (T=71, p=.518, z=-.647, r=-.129) was not statistically significant. This data shows that according to the SEVQ scale, learning the history of physics does not make a significant contribution to the epistemological development of students in the sub-domains assessed in the scale.

### *Interviews and analysis results*

After converting the qualitative data obtained from the interviews into quantitative data, the total scores a student could obtain in the rubric assessed were 0-14, and the scores that could be obtained in the SN, IC and CT sub-domains were 0-6, 0-4 and 0-4, respectively. The descriptive statistical data related to the scores the students obtained in the pre- and post-interviews are presented in Table 5.

**Table 5. Data for the Pre- and Post-Interview Score Analysis**

| Measurement | N | Total | | SN | | IC | | CT | |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Std. Dev. | Mean | Std. Dev. | Mean | Std. Dev. | Mean | Std. Dev. |
| Pre- | 25 | 11,28 | 0.843 | 4,28 | 0.678 | 3,12 | 0.332 | 3,88 | 0,332 |
| Post- | 25 | 11,92 | 0.862 | 4,76 | 0.663 | 3.24 | 0.436 | 3,92 | 0,277 |

According to the data in Table 5, it is seen that the students' pre- and post-interview scores in the analysis points to values that are again closer to the upper boundary. The data for the pre- and post-interviews also show that the students' scientific epistemological beliefs are closer to a constructivist point of view. This indicates that the qualitative data support the SEVQ scale data at this point.

It is seen in the data in Table 5 that the mean scores increased in the post-interview. According to the results of the Wilcoxon Signed Rank Test, which was performed to understand whether the difference compared to the pre-interview scores was significant, the difference between the pre- and post- interview values in the sub-domain SN (T=5,5, p=.005, z=-2.814, r=-.562 ) and the total scores of the interviews (T=4,5, p=.005, z=-2.801, r=-.560 ) was found to be statistically significant. The difference, however, with the sub-domains IC (T=.00, p=.083, z=-1,732, r=-0.346) and CT (T=6, p=.655, z=-.447, r= -.089) was not statistically significant. If it is considered that the difference between the total scores stems from the SN sub-domain, the conclusion may be drawn from the interview data that learning the history of physics does makes a contribution to student perspectives in this sub-domain.

The responses the students gave with respect to the sub-domains in the interviews were evaluated according to the student's code number, the domain code, the question code and the pre/post-interview code. For example, the code for the response of the 3rd student to the 3rd question on the SN sub-domain in the pre-interview was noted as S3.SN.Q3.Pre. Accordingly, the following summary can be made using samples from the students' views:

*SN-Sub-domain*

In responding to the first question in this sub-domain, the students generally exhibited constructivist views in both the pre- and post-interviews. It was seen that most of the students who exhibited empiricist views in the second question in the pre-interview set forth constructivist views in the post-interview. In the third question, however, the students expressing empiricist views in both the pre- and the post-interviews constituted the majority.

> *For SN.Q1*:
>
> S5.SN.Q1.Pre: "*Let me offer the example of quantum physics. It's not very possible for a scientist to develop everything that has been achieved in that field by him/herself. He/she has to benefit from things discovered before and build on this.*"
>
> S5.SN.Q1.Post: "*He/she may be influenced. The structure of knowledge is such that you have to build on what came before. Ultimately, work can be carried out on things previously discovered.*"

Twenty-three students exhibited similar constructivist views in both the pre- and the post-interviews. The other two students exhibited empiricist views in the pre-interview but set forth a constructivist view in the post-interview. For instance, S2.SN.Q1.Pre: *"Well, they can be influenced in their views but I think that wouldn't be very ethical, in other words, for it to be original, they should not be influenced."*

S2.SN.Q1.Post: *"They are influenced, for example, their students progress by following their examples. Aristotle's student was developing Aristotle's theory."*

*For SN.Q2:*

S25.SN.Q2.Pre: "*What else can they rely on, it's personal and it needs some effort*"

S25.SN.Q2.Post: "*Besides effort, that person is affected by other people, or by working together, their insights, their creativity, everything, it's not just effort*"

In this question 11 students' thoughts changed in this way. The difference between the pre- and post-measurement scores in the SN sub-domain largely stems from the change in this question.

*For SN.Q3:*

S13.SN.Q3.Pre: "*He can perform some experiments about those findings, really. It has to be verified with experiments in order to prove it.*"

S13.SN.Q3.Post: *"I can perform some experiments myself on the work you did. I can do research to see if I get different results; I can arrive at different conclusions to determine whether it's right or wrong?"*

Twenty-two students exhibited empiricist views on both the pre- and the post-test. These students believed that they could spend their own efforts to verify knowledge with a positivist approach without expecting scientists to discuss the matter and unite at a common point.

*IC-Sub-domain*

It was seen that a large portion of the students exhibited empiricist views regarding the first question in this sub-domain, both in the pre- and in the post-interview.

*For IC.Q1:*

S9.IC.Q1.Pre: *"They'll make a discovery, knowledge is always there, they simply discover it."*

S9.IC.Q1.Post: *"Knowledge exists and it is discovered. In other words, scientific information and laws already exist."*

S25.IC.Q1.Pre: *"They discover something that already exists. The atom already exists and there is knowledge about it, there is already something operating in nature and they explore only to become aware of this."*

S25.IC.Q1.Post: *"He exposes some knowledge that is already there. He explores. Everything happens within the framework of certain laws, within the framework of logic. We don't see the difference actually but they are things that are in operation. That's why they're discovered."*

Twenty-one students exhibited similar views in both the pre- and the post-interviews. It is seen that these students perceived natural phenomena and events as scientific information. They believed that the product of knowledge could be measured and treated as concrete fact.

*For IC.Q2:*

S21.IC.Q2.Pre: *"Of course. If we think about creativity as imagination, much scientific knowledge has been introduced in this fashion."*

S21.IC.Q2.Post: *"The wider a person's imagination, the more there is of what he can design in his/her head, and the more he can find things to discover."*

Twenty-four students formed similar sentences at the pre- and post-interviews. The view of one student thinking negatively changed in the post-interview in this direction.

*CT-Sub-domain*

The students largely responded to the two questions in this sub-domain with constructivist views. This can clearly be seen in the pre- and post-interview means in the CT sub-domain in Table 5.

*For CT.Q1:*

S10.CT.Q1.Pre: *"It would of course change, truths change with time in the dynamics of science. After a certain point, they believed that physics was finished but then quantum physics appeared and physics changed."*

S10.CT.Q1.Post: *"Of course, truths change with time in the dynamics of science. Truths are not definite."*

*For CT.Q2:*

S17.CT.Q2.Pre: "*There is classic physics and there is the theory of relativity. When you go up to the speed of light, everything goes haywire. Concepts change all of a sudden."*

S17.CT.Q2.Post: *"Concepts change. An example is when Aristotle spoke of time, the concepts then and the concepts now are as different as night and day."*

S3.CT.Q2.Pre: "They can change but I don't think they would disappear. Sometimes concepts don't change either but definitions related to a concept and properties change."

S3.CT.Q2.Post: "Concepts change. The concept of the atom was that it could not be divided but this changed. There might still be a concept that will completely change the atom but I can't think of it now, but it's possible."

*Student views about what they have gained from the course*

At the end of the post-interview, the students were asked to state what they gained from learning about the history of physics. Samples of their thoughts related to this question are the following (the thoughts that were expressed well):

S3: *"I learned a lot that I didn't know before in this field. I realized that I didn't know much about the history of physics. When I become a teacher, I think that I will provide a short summary of the history of physics at the beginning of the course. The scientists who work in the field have some interesting things in their lives."*

S6: *"I always thought that scientists support each other and try to help each other advance in their field. Just the opposite happen in some cases, it seems. I hadn't thought much about the fact that culture has an impact on science. I thought, for example, that science was more universal. Some of my thoughts have changed."*

S10: *"In order to teach somebody something, first of all you have to catch their attention. The history of physics does exactly this in this course. I think this course is very effective in catching the attention of the class and trying to do away with misconceptions. Scientists too have had the same misconceptions that students have. If we explain this as a process, saying that this concept was like such and such at first, and that scientists thought of it in one way and then concluded from their work that it was different, I think the student would feel better about him/herself."*

S13: *"I didn't know that scientists could influence each other so much or even that they can't stand each other sometimes.*

S14: *"Scientists have really affected each other, even though they may have come from different cultures."*

S:16: *"What really interested me was the times before the modern age, the primitive age, the age of the ancient Greeks, and how science and people were regarded. It was very enjoyable to learn how nature was perceived in those times and how things developed, and to see the difference in-between."*

S20: *"Because our field is physics, we are learning about where and how the knowledge we will be teaching originated, what the conditions were when this knowledge was developing, how and why this knowledge was attained, and basically the fundamentals of the science. Knowing about the personal qualities of the scientists responsible for this knowledge, learning about their work, and understanding where this information came from constitutes the foundation of knowledge."*

## DISCUSSION AND CONCLUSION

A review of the results obtained from the data collection instruments used in the study shows that the two tools generally supported each other. The only difference between them was the difference that emerged in the SN sub-domain in the interview results. Hofer (2004) reported in his study that interviews could be more effective in determining the extent of epistemological development. In this context, it was once again realized that the use of a scale could be inadequate in evaluating epistemological development and that studies should be supported with interviews.

At the end of the study, according to the evaluations made, it was found that learning about the history of physics had a positive effect on the development of the scientific knowledge of pre-service teachers and on their views concerning the importance of interaction and communication between scientists. This result is consistent with the approach of historical experimentation set forth by Galili & Hazan (2001). If it is considered that there are very few studies in this area, it can be said that knowledge of history is important in terms of an awareness of the importance of social interaction, especially while scientific knowledge is developing.

The following can be offered as an explanation as to why the students' empiricist views did not change with regard to SN.Q3 and IC.Q1 before and after the implementation. Positivism is a philosophical movement that is based on the logic that knowledge means phenomena and the most reliable knowledge can only be derived through observation and experiment (Fırat, 2006). When the student interview responses are examined, it can be seen that in SN.Q3, students focused more on verifying knowledge rather than on the interaction between individuals. This verification, according to the students, could be achieved with similar experiments and observations. In IC.Q1, however, it was seen that the students thought that knowledge consisted of the phenomena or events themselves. Both cases are consistent with the definition of positivism and it is seen that the students' views were in this direction. It can only be said at this point that learning history did not affect these views. Tsai (2006) and Erduran et al. (2007) stated in their studies that learning about the philosophy of science caused a development in epistemological views. In particular, Erduran et al. (2007) mentioned the importance of learning domain-specific science philosophy in their research. It has therefore been seen that in order to achieve the desired epistemological development, at some point, the history of the development of physics should be supported with the philosophy of physics.

Since the students in the study group were fourth-year students, their constructivist views in both their pre- and post-interview responses to SN.Q1, IC.Q2, CT.Q1 and CT.Q2 was not surprising to see considering that, as stated in studies in the literature (Brownlee, 2004; Brownlee et al., 2001; Çoban et al., 2011; Kienhues et al., 2008; Ng et al., 2010; Özgün-Koca & Şen, 2006; Tsai, 2006), that they were at a higher level in their education. For example, Çoban et al. (2011) asserted in their study, that students making the transition from classic physics to modern physics were able to learn that knowledge and theories could change. In fact, this is very clearly reflected in the students' views. At the same time, because the study subjects were students in the school of education, they had already participated in many teaching and learning activities that supported a constructivist approach and creative thinking. It can be said then that these activities contributed to the development of the students' views, albeit indirectly (Tsai, 2006). The results of the study are consistent with the literature.

Similar studies conducted with students at a lower educational level (middle school, high school) may give us an idea of the effect of learning about history at these levels. Also, because of the importance of introducing domain-specific history and philosophy in teaching, it will be useful to compare the results of the present study with those of studies in other disciplines.

It is furthermore believed that in the case of students in mathematical fields such as physics that have been caught up in numerical data and formulas and have no general interest in social studies, introducing them to the social dimensions of their area of interest could have an effect on their interest in and attitude toward the particular branch of science. Studies to explore this premise may be carried out.

The views of the students on the course also include some thoughts on how they can use what they have learned in their professional teaching. It would be useful for studies to be conducted to explore the effects of learning about the history of physics on the development of student thoughts, skills and similar factors involved in learning and teaching.

## REFERENCES

Abd-El-Khalick, F., & Lederman, N. G. (2000a). Improving science teachers' conceptions of nature of science: A critical review of the literature. *International Journal of Science Education*, 22, 665–701.

Abd-El-Khalick, F., & Lederman, N. G. (2000b). The influence of history of science courses on students' views of nature of science. *Journal of Research in Science Teaching*,37,1057–1095.

Balım, A. G., Kesercioğlu, T., İnel, D., & Evrekli, E. (2009). Fen öğretmen adaylarının yapılandırmacı yaklaşıma yönelik görüşlerinin farklı değişkenler açısından incelenmesi. *Ondokuz Mayıs Üniversitesi Eğitim Fakültesi Dergisi, 27,* 55-74.

Brooks, J.G., & Brooks, M.G. (1993). *In Search Of Understanding: The Case For Constructivist Classrooms*. Alexandria, VA: Association for Supervision and Curriculum Development.

Brownlee, J., Purdie, N., & Boulton-Lewis, G. (2001). Changing epistemological beliefs in pre-service teacher education students. *Teaching in Higher Education,* 6(2), 247-268.

Brownlee, J. (2004). An investigation of teacher education students' epistemological beliefs: Developing a relational model of teaching. *Research in Education,* 72, 1-18.

Chai, C. S., Teo, T., & Lee, C. B. (2009). The change in epistemological beliefs and beliefs about teaching and learning: a study among pre-service teachers. *Asia-Pacific Journal of Teacher Education,* 37(4), 351–362.

Çınar, O., Teyfur, E., & Teyfur, M. (2006). İlköğretim okulu öğretmen ve yöneticilerinin yapılandırmacı eğitim yaklaşımı ve programı hakkındaki görüşleri. *İnönü Üniversitesi Eğitim Fakültesi Dergisi,* 7(11), 47-64.

Çoban, G. Ü., Ateş, Ö., & Şengören, S. K. (2011). Epistemological Views of Prospective Physics Teachers. *International Online Journal of Educational Sciences,* 3(3), 1224-1258.

Erduran, S., Bravo, A. A., & Naaman, R. M. (2007). Developing Epistemologically Empowered Teachers: Examining the Role of Philosophy of Chemistry in Teacher Education. *Science & Education*, 16(9-10), 975-989.

Falk, R. (2000). History of Physics in Science Teacher Training in Oldenburg. *Science & Education,* 9, 399–402.

Fırat, N. Ş. (2006). Pozitivist Yaklaşımın Eğitim Yönetimi Alanına Yansıması, Alana Getirdiği Katkı ve Sınırlılıkları. *Dokuz Eylül Üniversitesi Buca Eğitim Fakültesi Dergisi,* 20, 40-51.

Flores, B. B. (2001). Bilingual education teachers' beliefs and their relation to self-reported practices. *Bilingual Research Journal*, 25(3), 251–275.

Galili, I., & Hazan, A. (2001). The Effect of a History-Based Course in Optics on Students' Views about Science. *Science & Education,* 10, 7–32.

Gömleksiz, M.N. (2007). Yeni İlköğretim Programına İlişkin Öğretmen Görüşlerinin Çeşitli Değişkenler Açısından Değerlendirilmesi. *Eğitim Araştırmaları*, 27, 69–82.

Hammer, D., Elby A., Scherr R., & Redish E. F. (2005). Resources, framing, and transfer. In: J. Mestre (Ed.), *Transfer of learning from a modern multidisciplinary perspective* (89–119). Greenwich, CT: Information Age Publishing.

Hashweh, M. Z. (1996). Effects of Science Teachers' Epistemological Beliefs in Teaching. *Journal of Research In Science Teaching*, 33 (1), 47-63.

Hofer, B. K. (2004). Introduction: Paradigmatic approaches to personal epistemology. *Educational Psychologist*, 39(1), 1–3.

Ioannis, V. (2005). Teachers' epistemological beliefs: A case study of teachers' meaning of the process of explanation. *Science Education International,* 17 (2), 141-153.

Karacaoğlu, Ö. C., & Acar, E. (2010). Yenilenen programların uygulanmasında öğretmenlerin Karşılaştığı sorunlar. *Yüzüncü Yıl Üniversitesi, Eğitim Fakültesi Dergisi,* 7(1), 45-58.

Kienhues, D., Bromme, R., & Stahl, E. (2008). Changing epistemological beliefs: The unexpected impact of a short-term intervention. *British Journal of Educational Psychology,* 78, 545–565.

Knobloch, N. A., & Hoop, S. E. (2005, September). *Preservice teachers' epistemological beliefs, attitudes, and behaviors regarding instructional* *planning*. Proceedings of the 2005 AAAE North Central Agricultural Education Research Conference, Columbus, OH, 207-221.

Koponen, I.T., Mäntylä, T., & Lavonen, J. (2004). The Role of Physics Departments in Developing Student Teachers' Expertise in Teaching Physics. *European Journal of Physics*, 25, 645–653.

Koponen, I.T., & Mäntylä, T. (2006). Generative Role of Experiments in Physics and in Teaching Physics: A Suggestion for Epistemological Reconstruction. *Science & Education,* 15, 31–54.

Lederman, N. (1992). Students' and teachers' conceptions of the nature of science: A review of research. *Journal of Research in Science Teaching, 29*, 331-359. doi: 10.1002/tea.3660290404

Lederman, N.G., Abd-El-Khalick, F., Bell, R. L., & Schwartz, R. S. (2002). Views of nature of science questionnaire: Toward valid and meaningful assessment of learners' conceptions of nature of science. *Journal of Research in Science Teaching, 39*, 497-521.

Lin, H. S., & Chen, C. C. (2002). Promoting preservice chemistry teachers' understanding about the nature of science through history. *Journal of Research in Science Teaching*, 39, 773–792.

Marra, R. M., & Palmer, B. (2005). University science students' epistemological oriantations and nature of science indicators: How do they relate?. *Science Education International,* 18 (3), 165-184.

MEB. Fizik Öğretmeni Özel Alan Yeterlikleri(2011, January). Retrieved from http://otmg.meb.gov.tr/alan_fizik_ortaogretim.html

Ng, W., Nicholas, H., & Williams, A. (2010). School experience influences on pre-service teachers' evolving beliefs about effective teaching. *Teaching and Teacher Education,* 6, 278–289.

Ocak, G. (2010). Yapılandırmacı Öğrenme Uygulamalarına Yönelik Öğretmen Tutumları. *GÜ, Gazi Eğitim Fakültesi Dergisi,* 30 (3), 835-857.

Özgün-Koca, S.A., & Şen, A. İ. (2006). The beliefs and perceptions of pre-service teachers enrolled in a subject-area dominant teacher education program about ''Effective Education''. *Teaching and Teacher Education*, 22, 946–960.

Patton, M. Q. (2002). *Qualitative research and evaluation methods*. Sage Publication: USA.

Seroglou, F., & Koumaras, P. (2001). The Contribution of the History of Physics in Physics Education: A Review. *Science & Education,* 10, 153–172.

Schraw, G., & Olafson, L. (2002). Teachers' epistemological world views and educational practices. *Issues in Education*, 8(2), 99–149.

Stacey, P.S., Brownlee, Joanne, M., Thorpe, K. J., & Reeves, D. (2005). Measuring and manipulating epistemological beliefs in early childhood education students. In *International Journal of Pedagogies and Learning*, University of Southern Queensland, Faculty of

Education, University of Southern Queensland, Toowoomba, Queensland, pp. 6-17.

Teixeira, E. S., Greca, I. M., & Jr Freire, O. (2012). The History and Philosophy of Science in Physics Teaching: A Research Synthesis of Didactic Interventions. *Science & Education,* 21(6), 771-796.

Tsai, C.-C. (2002). Nested epistemologies: science teachers' beliefs of teaching, learning and science. *Int. J. Sci. Educ.*, 24 (8), 771–783.

Tsai, C.-C., & Liu, S.-Y. (2005). Developing a Multi-dimensional Instrument for Assessing Students' Epistemological Views toward Science. *International Journal of Science Education*, 27 (13), 1621-1638.

Tsai, C.-C. (2006). Reinterpreting and reconstructing science: Teachers' view changes toward the nature of science by courses of science education. *Teaching and Teacher Education,* 22, 363–375.

Tsai, C.-C. (2007). Teachers' Scientific Epistemological Views: The Coherence with Instruction and Students' Views. *Sci. Ed.,* 91, 222 - 243.

Tsai, C.-C. (2009). The development of science activities via on-line peer assessment: the role of scientific epistemological views. *Instr. Sci.*, 37, 293–310.

Trumbull, D., & Slack,M. J. (1991) Learning to ask, listen, and analyze: using structured interviewing assignments to develop reflection in preservice science teachers. *International Journal of Science Education*, 13 (2), 129–142.

Topcu, M. S. (2011). Turkish Elementary Student Teachers' Epistemological Beliefs and Moral Reasoning. *European Journal of Teacher Education*, 34(1), 99–125.

Uysal, E. (2010). *A Modelıng Study: The Interrelationships Among Elementary Students' Epistemological Beliefs, Learning Environment Perceptions, Learning Approaches and Science Achievement*. (Unpublished doctoral thesis). The Middle East Technical University, Ankara.

Yıldırım, A., & Şimşek, H. (2005). *Sosyal Bilimlerde Nitel Araştırma Yöntemleri* (6. baskı). Ankara: Seçkin.