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# The Effect of Documentary Films on Preservice Science Teachers' Views of Nature of Science

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**ABSTRACT** Understanding the nature of science, one of the most important dimensions of scientific literacy, is regarded as an absolute necessity in science education. To teach students the nature of science, science teachers should emphasize the nature of science in the classrooms. This is possible through the training of science teachers with knowledge of the nature of science. In this study, documentary films were used to teach preservice science teachers about the nature of science. This study aims to investigate the effect of nature of science course conducted with documentary films on preservice science teachers' views of nature of science. The study, in which the experimental design was used, was conducted with 30 preservice teachers in nature of science and history of science courses. Throughout the courses, documentary films were watched, and nature of science aspects of the documentary films was discussed. The Views of Nature of Science Questionnaire (VNOS-C) was used as pre-test and post-test, and the data were analyzed with SPSS. As a conclusion, preservice science teachers' views regarding the nature of science were enhanced after the implementation.

**Keywords** Nature of science, Preservice science teachers, Documentary films

## 1. INTRODUCTION

The developments in science and technology have affected the education policies of countries, and these alter education systems necessary. In parallel to those alterations, significant education institutions like the American Association for the Advancement of Science (AAAS) and the National Research Council (NRC) emphasize that educating each individual as scientifically literate is one of the main goals of science education (American Association for the Advancement of Science, 1990; National Research Council, 1996). In this context, understanding the nature of science (NOS), which is one of the key components of scientific literacy, is accepted as an absolute need in science education (Meichtry, 1992; Lederman, 2007).

Nature of science is typically described as an epistemology of science, values, and beliefs inherent to the scientific knowledge, science as a way of knowing, and also it includes the historical, philosophical and sociological aspects of science (Lederman, 1992). Nature of science involves understanding what science is and what role it plays; who scientists are and what roles they play; the nature of scientific evidence, observations, facts, rules, laws, and the scientific method; and how science is done (Taşar, 2003).

Since nature of science has a complex structure, which includes different disciplines like sociology of science, philosophy of science and history of science, researchers focus on specific features to make definitions and put emphasize on these features. These features, which are called aspects of NOS, are: Scientific knowledge is tentative (subject to change); science is empirically based (based on or derived from observation of the natural world); science is inferential, imaginative and creative; science is subjective and theory-laden; science is socially and culturally embedded (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002).

Because technology has become an essential part of education, videos, movies, and documentaries have started to play a role in the education process. Videos have become an important teaching tool in terms of visualizing abstract terms and appealing to multiple senses. Numerous research studies about the effects of using documentaries in teaching NOS, which is a part of science education, are

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encountered in the literature. Seçkin-Kapucu, Cakmakci & Aydoğdu (2015) emphasize that documentaries linked to science content would be fruitful for teaching NOS to secondary school students about specific topics. Moreover, in research about teaching NOS, it is stated that students also want to benefit from videos and activities in lessons (Dereli, 2016).

Science teachers have a significant influence on their students for learning NOS. A science teacher needs to have information about NOS to include activities about NOS in his/her lessons, which means science teachers must have a new and updated point of view about NOS if the opinions of students about NOS are to be improved (Sorensen Newton & McCarthy, 2012). In a study about Science Technology Society course, it is stated that introducing scientific videos to preservice science teachers can be useful especially help them understand that science is affected by the social and cultural values of the society. When the studies regarding this subject are reviewed, it is implied that the interests of students in science and the scientific literacy level of students would be increased if science concepts were taught via science-fiction movies (Efthimiou & Llewellyn, 2007). In a two-week study with 11 teachers that was conducted by Bloom, Binns & Koehler (2015), the effects of documentaries in the subject of teaching NOS were researched and it is stated that these effects are limited. In the suggestions of the same study, it is stated that these effects should be investigated by applying these studies over a more extended period. In this study, documentaries about scientific events and the lives of scientists were watched by preservice science teachers (PST) who attended the NOS course for 12 weeks and the effects of these documentaries on the perceptions of PST were researched.

Research questions; (1.) Is there a statistically significant difference between posttest scores of experimental and control groups on understanding NOS? (2) Is there a statistically significant difference between pretest and posttest scores of the experimental group on understanding NOS?

## 2. METHOD

### 2.1 Research Design

In this research, quasi-experimental design with the pretest-posttest control group was used to determine the effects of documentary films on PST' understanding of NOS as seen in Table 1. This design refers to the application of the experiment and the interpretation of data without random assignment (Cook, Campbell & Shadish, 2002). The independent variable of the study was documentary films as a way of teaching NOS, and the dependent variable is preservice teachers' understanding of NOS.

**Table 1** Design of the research

| Group | Pre-test | Treatment | Post-test |
|---|---|---|---|
| Experimental group | VNOS-C | Documentary films | VNOS-C |
| Experimental group | VNOS-C | Regular content | VNOS-C |

Before and after the course, VNOS questionnaire was applied to PST, and the effect of the documentaries on the views of PST' NOS understanding was evaluated with a comparison of pre- and post-tests of the experimental and control group.

### 2.2 Sample / Participants

This study was conducted in the "Nature of Science and History of Science" course in the 2017-2018 spring term. Participants of this study consisted of third-grade preservice teachers who were studying in the Science Teaching program and taking this course. The preservice teachers had a similar background; they took the same courses in the first two years of the college and had no experience about NOS. Sixty preservice teachers were included in this study who continued to take this course and participate in pre and post-tests. The experimental group consisted of 30 preservice teachers (12 females and 18 males), and the control group consisted of 30 (14 females and 16 males) preservice teachers. The age of the sample was about 20 years old. The experimental group and the control group were chosen randomly.

### 2.3 Intervention

The study was implemented in science teaching program students at a state university in Turkey in the "Nature of Science and History of Science" course in the 2017-2018 spring term. The course was taught for two hours per week and spanned 14 weeks (one semester). Pre and post-tests were applied at the first and the last week of the semester. At the remaining 12 weeks, documentary films were used as a way of teaching NOS at the experimental group, regular content was used for teaching science at the control group. Both groups were taught by the same instructor and held explicit reflective discussions about NOS. All the activities and documentary films were addressed the seven targeted aspects of NOS.

Experimental group. Documentaries about scientific events and the lives of scientists were watched by experimental group and discussions about these documentaries were made via the questions asked by the instructor. Eleven documentaries were chosen carefully by the researcher and instructor which would be suitable to highlight NOS aspects like the characteristics of scientific knowledge, progress and historical periods of science, the science-society relation and the lives of scientists. Table 2 shows the content of documentary films and NOS aspects emphasized within each documentary films. Documentary films have been watched in each lesson, and questions have been directed to pre-service science teachers by pausing the video at the points which gives the possibility to relate aspects of NOS and discussions were provided by specifying the ideas of the pre-service science teachers. For example, before the documentary film about Galileo "Does beliefs and culture of a society affect science?" was asked to PST and they were let to discuss it briefly. At the end of the documentary, the same question was asked and after PST had stated their opinions, the instructor stressed the social and cultural aspect of NOS. The length of each documentary was about 45-60 mins and watching each documentary and the discussion took two lesson hours.

Control group. The control group was received regular content which was determined by the Higher Education

**Table 2** Introduction of documentaries and NOS aspects

| Introduction of Documentaries | NOS Aspects |
|---|---|
| **1.Mankind-The Story of All of us: Inventors 1&2:** In this documentary, the adventure of mankind's survival is told. We witness mankind challenging dangers while trying to find new places and resources on earth. This documentary unrolls the story of mankind existing on earth. Beginning with the first man's existence, human beings will continue with the adventure of hunting and gathering, learning about the use of agricultural activities, which is a great revolution, and how to learn to use various tools of human beings and learn to survive by developing them. After that, the first battles emerge as a result of the negative aspects of agricultural activities and the emergence of disputes across borders. When it puts up a fight to survive in its early days, mankind uses his effort to destroy his own kind in time and mankind now consumes the resources on Earth rapidly. | *The development of scientific information, the science-technology interaction, the processes of science history and the interaction of science with the social and cultural environment that it belongs to are mentioned.* |
| **2. Avicenna "The Emperor of Medicine":** The documentary, which takes place in the documentary series named 'The candles of Asia' that highlight scientific works in the Islamic world in the Middle Ages, is about Avicenna's life. This documentary gives information about Avicenna's life as it gives information about his scientific study understanding. Avicenna, a Muslim Persian scientist and philosopher, had a good education from a famous scientist of his age. With the help of his intelligence and strong memory, he reached his teachers' levels and had in-depth knowledge in various subjects like philosophy, literature, mathematics and medicine at the age of 14. He focused on medicine and improved new treatments. He got the 'Doctor' title at the age of 19. Avicenna, who was accepted as one of the best doctors of his age, carried out his work without sleeping at night and revealed many works at a young age. 'Kitabu'ş Şifa', one of the biggest works of Avicenna, is an encyclopedia which gathers the information of his age in areas of Logic, Physics, Geometry, Astronomy, Mathematics, Music and Metaphysics. 'Kanun fi't-Tıbbise, maybe Avicenna's most famous work, has been taught as a textbook in Europe for 600 years and is named as the Bible of Medicine. | *The subjective aspect of science, the characteristics of scientists and their personal lives, and the interaction of science with the social and cultural environment that it belongs to were mentioned.* |
| **3. Al-Farabi "Philosophy Courses in Transoxiana":** The documentary, which handles the famous Islamic philosopher Al-Farabi's scientific works in science, art, and philosophy without isolating them from the cultural, social and political atmosphere of the era, can be interpreted as a productive and extraordinary trip to culture and humanity, as well as being a biographical documentary. Al-Farabi, known as the first Muslim philosopher, produced works about philosophy and walked from city to city by following in Aristotle's footsteps. He made an effort to ensure that philosophy and religion did not interfere with each other. | *In this documentary, the subjective and experimental factors of NOS are mentioned. In addition to this, science and society relation is also mentioned.* |
| **4. The life of Albert Einstein:** The documentary, which starts with Einstein's youth years, mentions Einstein's personal life as well as his academic life. His close relation with theoretical physics started when he moved to Switzerland after quitting his school in Germany because of its education style and family problems. Einstein, who had a lively personal life, started his patent officer job when he broke up with his great love and student Milena Maric. The science environment, which became very political because of the World Wars, deeply affected Einstein's life. Einstein, who was known as anti-war, went to the USA as a refugee after he had certified the theory of relativity and settled there. Einstein, who did not lose his hope and inspiration, said: "The important thing is not to stop questioning; curiosity has its own reason for existing." Einstein, who kept on having relationships in his late years, found himself in a big challenge. | *In this documentary, the relation of science with the society that it is produced in, the place of imagination in science, and the relation of scientific theory and law are mentioned. In addition to this, the subjectivity of scientific information and the private lives and characteristics of scientists are also mentioned.* |

*continued*

**Table 2** Introduction of documentaries and NOS aspects (*continued*)

| Introduction of Documentaries | NOS Aspects |
|---|---|
| **5. Who is Galileo Galilei? What contribution has he made to science and technology?:** Galileo, who shook the understanding of science in the Medieval Age, caused a revolution by questioning the church belief which had the control of the era, and Aristotle's knowledge. Galileo was born in Italy in the 16th century and studied there in areas of medicine, mathematics, and philosophy. Galileo, who had been doing experiments about Physics since his early years, got his professorship at the age of 25. In 1609, he invented a more advanced telescope by examining a telescope, and he had a chance to make observations no one had done before. According to his observations, he suggested the heliocentric model and he published his studies about it. Since he collided with the church which advocated the geocentric model, he was judged more than once by the Vatican. Teaching his theories and publishing his books was banned and he was sentenced to lifetime house confinement. Galileo became a symbol for the science-religion conflict due to his challenge with the church in his lifetime. | *In this documentary, the importance and difference of observation and implication while science is produced, the interaction of science with social and cultural values and especially religion-science are mentioned. In addition to these, the science-technology relation, the experimentality of science, the change of scientific information in time, and the paradigm change in science are also mentioned in this documentary.* |
| **6. Nikola Tesla Documentary:** Nikola Tesla undoubtedly is one of the most distinctive personalities of science history. Trying to understand his ideas took many years. Tesla, who said that his photographic memory and creative genius were a heritage from his mother, started to make inventions in his early years. Despite illnesses and hardships in his childhood, he never quit and made numerous inventions including earthquake machines, death rays, and universal wireless energy. We get closer to the mind and ideas that are behind those strange inventions. | *In this documentary, the subjectivity of science, the place of creativity and imagination in science, and the personal lives of scientists are mentioned.* |
| **7. Thomas Edison Documentary:** In this documentary, which gives us the possibility to know Edison better, we witness Edison, whose life affected our lives. Edison, who was born in 1847 in the USA, started to be interested in science from his early years. He started to do his own experiments at the age of 10 by creating his own lab at home. Edison made many inventions in his life and his patents were accepted in many countries. The inventor, who has many inventions like the gramophone, carbon microphone and the cinema machine, also founded his own company by showing entrepreneurship and he succeeded in making his inventions commercialized. | *In this documentary, the effect of scientific information on the society that it is produced in and the effect of society on science, the place of imagination and creativity in science, the science-technology relation and the importance of experiments in science are mentioned.* |
| **8. Time Bending Beyond the Universe**: A fact which is accepted as stable and accurate anywhere in the universe means it is universal. But according to Albert Einstein's Theory of Relativity, this is not true. This means that time is not the same in all the universe, it changes from observer to observer, and it is relative. As a result of mass which creates warps in space-time, time bends and time flows more slowly from the observer who is at that place to another one. Moreover, time is not universal right there. Let me explain time bending with a more accessible example. Lay a sheet on a bed without leaving wrinkles. Here, the sheet without wrinkles represents two a dimensional space-time plane. When we put an iron marble on this sheet, the marble will sink into the sheet a little bit. Just like in the example, time also can be bent by a mass represented by a marble. When the mass gets bigger, the bending will be greater. If the mass is more than the spaceplane can carry, the space plane will collapse and a black hole will exist. | *In this documentary, the importance of observation and deduction in the production of scientific knowledge, the paradigm change and the scientific laws and the theories that scientific information can change and develop over time are mentioned.* |
| **9. Isaac Newton Documentary:** Isaac Newton, who was born in the UK in 1642, spent most of his childhood with his grandmother because of family problems. Since he was curious about science, he read many books and designed various tool models. He had to work in various jobs besides his education life because of his poor family conditions. He started to study in Cambridge in 1661 but he had to pause because of the plague epidemic. In that period, he moved to a farm and continued to study there. After the epidemic, he came back to Cambridge University and he continued to work there as a mathematics professor. He focused on mechanics and he published an important work named Principia. | *In this documentary, the personal characteristics of scientists, the subjective side of scientific information, the importance of imagination and creativity in science, science-technology and the interaction of science with the society that it is produced in are mentioned.* |
| **10. Encounter with Pluto:** Pluto, which is billions of miles away, is one of the mysterious celestial bodies in our solar system. A space vehicle named New Horizons was taken into service to investigate Pluto more closely and sweep the mysteries away. The space vehicle, whose duty is to study Pluto and its satellites, has been traveling in the solar system since January 2006 in order to reach Pluto. New Horizons, which has been traveling for 10 years to complete its duty, will only have a few minutes to view Pluto. If it ends its duty, we will have the chance to see the deepest parts of the solar system for the first time. | *This documentary emphasizes the importance of science experiments, observations and inferences and changeable scientific knowledge.* |

Council (HEC, 2018). The content was "Philosophy of science (Content and purpose of philosophy, paradigms, philosophical thoughts and its effect on development of science), Nature of knowledge (ontology, epistemology, nature of scientific concepts, scientific knowledge and it's characteristics), History of science, Scientific literacy and NOS aspects , The role of NOS in curriculum and teaching. NOS (Nos teaching approaches and NOS assessment), NOS activities (integrated and non-integrated NOS activities), NOS and science, technology and society relation" according to Science Teaching Undergraduate Program (HEC, 2018). Lessons were taught mostly by powerpoint presentations. Both integrated and non-integrated NOS teaching activities helped PST to learn NOS. For example, for explaining the distinctions between observation and inference, both tricky tracks activity developed by Lederman and Abd-El-Khalick (1998) and atom models were used. After the activities, reflective discussions were guided by the instructor by asking questions about emphasized NOS aspects.

### 2.4 Data Collection Instruments

The questionnaire (VNOS-C), which consists of open-ended questions, was applied twice as pre- and post-application in order to evaluate the effect of the documentaries watched in the "Nature of Science and Science History" course on the views of preservice teachers about NOS. VNOS (Views of Nature of Science) questionnaires, whose most basic form was created by Lederman and O'Malley (1990), were designed to reveal students' thoughts about one or more than one NOS fact and they consist of open-ended questions which give students the chance to state their thoughts without being under the effect of individual options. In their studies about the reliability and validity of VNOS questionnaires, which were conducted in-depth, Lederman, Abd-El-Khalick, Bell, & Schwartz (2002) stated that VNOS had been a valid measuring tool in order to understand the perspectives of students about NOS. In this study, a VNOS-C questionnaire which was suitable for preservice teachers was used and there are different versions that are suitable for different age group levels. The survey, which evaluates the opinions of preservice teachers about NOS, consists of 10 open-ended questions.

### 2.5 Data Analysis

Primarily, the answers which were given to the questions in the VNOS-C questionnaire by preservice teachers were classified as naive, transitional and informed, similar to Khishfe and Lederman's (2006). Each aspect of NOS is not questioned in only one item in this questionnaire which sought the opinions of preservice teachers about the aspects of NOS. So, the answers given to all questions in the questionnaire were examined carefully in order to classify each element of NOS. The answers of preservice teachers were classified as naïve when a preservice teacher didn't demonstrate any meaningful understanding related to the element in question and informed when a preservice teacher provided evidence of meaningful understanding related to the aspect of each question. In addition to this, if a preservice teacher demonstrated a useful understanding of an aspect but also had some misconceptions, the answers were classified as transitional. After this, answers of preservice teachers for each aspect were scored from 0 to 2 for naive, transitional and informed. Some examples of preservice teachers' answers are shown in Table 3.

PST' responses to the VNOS-C were scored by two researchers (one studied NOS on her master degree, the other on his Ph.D.) independently. Then the analyses were compared, and reliability was calculated as %90 (Miles and Huberman, 1994). The inconsistencies between researchers were resolved through discussion. Data which were obtained at the beginning and end of the course were compared with the help of SPSS 16.0 statistical program.

**Table 4** Test of normality

| Measurement | Group | Shapiro-Wilk statistic | df | Sig. | Skewness | Kurtosis |
|---|---|---|---|---|---|---|
| Pre-test | Experimental | ,947 | 30 | ,144 | ,280 | -,684 |
| Post-test | Experimental | ,940 | 30 | ,094 | ,397 | ,427 |
| Pre-test | Control | ,947 | 30 | ,144 | -,002 | -,992 |
| Post-test | Control | ,941 | 30 | ,096 | -,504 | -,459 |

## 3. RESULT AND DISCUSSION

### 3.1 Results

In this study, the VNOS-C questionnaire was applied twice as pre-test and post-test to determine the effect of documentary films on the PST' NOS understandings. Results obtained from the analysis are given below in the tables according to the research questions.

#### Preliminary tests

As a preliminary analysis, all the data obtained was tested for normality in order to decide if the data had parametric value or not as shown in Table 4. Because the sample was less than 50, the Shapiro-Wilk test was applied to determine if the data exhibit a normal distribution (Büyüköztürk, 2011). The test results showed that the data was normally distributed therefore, parametric tests were chosen to analyze the effect of documentary films.

According to the test results given in the table, significance values are higher than 0,05. Furthermore, kurtosis and skewness values are between the range of -1 to +1. These results indicate normal distribution (Hair, Black, Babin & Anderson; 2013). Thus, independent samples t-test was used to compare the group scores, and paired samples t-test was used to determine the effect of the documentary films on understanding NOS of the experimental group.

Before comparing means with independent samples t-test, homogeneity of variance was tested as tabulated in Table 5. The assumption on homogeneity between the control and experimental groups was checked by investigating Levene's Test of Equality of Error Variances.

According to the test results, the significance value is greater than 0,05. Therefore, the homogeneity of regression assumption was met.

**Table 3** Examples of PST' answers

| NOS aspects | Naive views | Transitional views | Informed views |
|---|---|---|---|
| The empirical NOS | *Science is an empirical-based discipline. So scientists conduct experiments on their labs to get solid evidence and without an experiment, you cannot prove your theory.* | *Scientists cannot always perform experiments to proof scientific claims, sometimes their studies are based on observation of the world.* | *Doing an experiment is a way of scientific investigation, but not the only way. You can't always rely on experiments, for instance, Einstein didn't conduct an analysis to explain gravitational waves. Knowledge can be derived from observations, imagination as well as experiments.* |
| The tentative NOS | *Theories can change over time since they are not proven. But once they've proven they become laws and laws are specific and cannot change.* | *Yes, theories can change over time. Finding new evidence can change theories. For example, from Democritus's days till these days, atom theories had changed due to new evidences.* | *Since the scientific information we know about the natural world increases, we develop better tools to understand it or we gain a different perspective on the phenomenon we investigate. Because of that, scientific knowledge can change.* |
| The theory-laden NOS | *Because of the missing evidence, scientists had to guess the missing parts to complete the theories. When the truth comes out, they will reach a consensus on one of the theories.* | *Because of the lack of certain knowledge, it is difficult to explain why and scientists have different opinions because they are different.* | *Even if scientists use the same data, they make different experiments, observations, and they can reach different conclusions. Their imagination, beliefs or their pasts can affect their investigation.* |
| Distinctions between observation and inference | *Scientists are not certain about the atom because they cannot see it and they are still investigating how an atom looks like.* | *The evidence they gathered with the help of electron microscopes and the experiments such as Rutherford's gold foil experiment, scientist have an idea what atom looks like.* | *Even if they cannot directly observe the atom, based on the observations, experiments they conduct and using their creativity they can make a model of an atom that explains to us how an atom supposed to look like.* |
| The creative and imaginative NOS | *No, they don't. Because if they used their imagination then the scientific knowledge they've derived would not be reliable. That's the difference between science and other disciplines.* | *I think scientists use their creativity in their work. They think different than normal people and they are curious about the natural world. So they come up with interesting ideas, questions or inventions by their creative minds.* | *Sometimes phenomenon cannot be observed directly, like atoms, genes etc. Creativity and imagination play a big role in these situations. For example Einstein's thought experiments. He used his imagination at all stages of the experiment.* |
| Distinctions and Relationship between Scientific Theories and Laws | *Theories are like predictions; they haven't been proven by enough data. When they are proven by experiments they become absolute and called laws.* | *The theory is not a certain scientific knowledge that is agreed by all scientists like a law. But they are different kinds of scientific knowledge and can't become one and another.* | *Theories are explanations of natural phenomenon whilst laws are descriptions of the relationships among this phenomenon. Both of them are well supported by evidence. There is no hierarchical relation.* |
| Social and Cultural Influences on Scientific Knowledge | *Science is universal; the rules and facts are valid and same all around the world. Science should not be influenced by cultures and beliefs. Otherwise it wouldn't be certain.* | *Science can be affected by society's ideas or belief yet it still remains universal.* | *Science is influenced by cultural and social values. For example, Galileo's ideas about the solar system were forbidden because it was against the church. This shows us how can scientific progress can be effected easily by beliefs of a society* |

**Table 5** Levene's test for equality of variances

| Details | | Levene's Test for Equality of Variances | |
|---|---|---|---|
| | | F | Sig. |
| Experimental & control group pre-tests | Equal variances assumed | ,652 | ,423 |
| | Equal variances not assumed | | |

## Results and Discussion on Comparison Between the Experimental and Control Groups

For testing the effectiveness of documentary films on PST' NOS understanding, VNOS-C scores were analyzed. The comparison results of understanding of the PST' NOS understandings were presented in Table 6.

As seen in Table 6, the pre-test mean scores of experimental and control groups were 4,13 and 4,27 respectively. After the intervention, the mean scores of the control group were 6,27 while the mean scores of the experimental group which was taught with documentary films were 8,53. The results show that there was an increase in the mean scores of the preservice teachers in both groups. Independent samples t-test was conducted to determine whether the post-test scores showed a significant difference. As a result of the analysis, it was found that the scores between post-tests of experimental and control group differed meaningfully in favor of the experimental group. This means that using documentary films had a significant effect on PST' NOS understandings positively.

**Table 6.** Mean and standard deviation values of the experimental and control groups

| Tests | Groups | N | X | Sd | df | t | P |
|---|---|---|---|---|---|---|---|
| Pre-test | Experi-mental | 30 | 4,13 | 1,852 | 58 | -,260 | 0,796* |
| | Control | 30 | 4,27 | 2,116 | | | |
| Post-test | Experi-mental | 30 | 8,53 | 1,852 | 58 | 3,972 | 0,000* |
| | Control | 30 | 6,27 | 2,518 | | | |

*p<0,05

As VNOS-C scores of experimental and control groups were compared by NOS aspects, it is seen that there was no statistically significant difference between experimental and control groups regarding "Distinctions and Relationship between Scientific Theories and Laws" and "Social and Cultural Influences on Scientific Knowledge" aspects. As it is seen in Table 7, there was a statistically significant difference between experimental and control groups regarding other five aspects which are "The Empirical NOS", "Distinctions between observation and inference", "The tentative NOS", "The Theory-Laden NOS" and "The Creative and Imaginative NOS". Considering mean scores, at all aspects experimental group scores were higher than control group scores. However, according to the independent samples t-test, there was a statistically significant difference between groups in five of the aspects in favor of the experimental group.

### Results and Discussion on Comparison Between the Experimental and Control Groups

Under this title, PST' NOS understandings in the experimental group before and after the intervention are presented. As it is seen in Table 8, majority of the PST' views were transitional in terms of "The Empirical NOS", "Distinctions between observation and inference", "The tentative NOS", "The Theory-Laden NOS" and "The Creative and Imaginative NOS" aspects in the experimental groups before the intervention. In addition to this PST's views regarding "Distinctions and Relationship between Scientific Theories and Laws" and "Social and Cultural Influences on Scientific Knowledge" aspects were naïve at the beginning.

The results presented that after the intervention, the majority of PST's views about "The Empirical NOS" and "The tentative NOS" aspects have changed from transitional to informed and "Distinctions and Relationship between Scientific Theories and Laws" and "Social and Cultural Influences on Scientific Knowledge" aspects have transformed from naïve to transitional. Moreover, only one PST held naïve views on "Distinctions between observation and inference" and "The Creative and Imaginative NOS" aspects and no PST left who held naïve views on "The Theory-Laden NOS" aspect after the intervention.

The results presented in Table 8 have shown that teaching with documentary films is an effective way to enhance understandings of PST on certain NOS aspects. In order to determine whether this increase is statistically meaningful or not, paired-samples t-test was conducted.

According to Table 9, paired-samples t-test results showed that there is a statistically significant difference between the pre-test and post-test. As it is seen in the table, mean scores of the experimental group have increased from 4,13 to 8,53 after the intervention. In order to explain the results more detailed, paired-samples t-test was conducted for each NOS aspect.

Paired samples t-test results of pre-test and post-test scores of PST has shown that there is a statistically significant difference between pre-test and post-test scores of PST on NOS understanding in each aspect except for one; the tentative NOS. Even though there was an increase according to the mean scores, there is no statistically significant difference regarding the tentative NOS aspect. To overall, results of the tests have shown that using documentary films is effective to teach PST NOS.

## 3.2 Discussion

In this study, the effects of documentary films on PST' views about NOS was investigated. According to the table 7, it was found that there was a significant difference

**Table 7.** Mean and standard deviation values of NOS aspects between groups

| NOS aspects | Groups | N | X | Sd | df | t | p |
|---|---|---|---|---|---|---|---|
| The Empirical NOS | Control | 30 | 1,23 | 0,568 | 29 | 2,062 | 0,044 |
| | Experimental | 30 | 1,57 | 0,679 | | | |
| Distinctions between observation and inference | Control | 30 | 0,90 | 0,758 | 29 | 2,443 | 0,018 |
| | Experimental | 30 | 1,33 | 0,607 | | | |
| The tentative NOS | Control | 30 | 0,83 | 0,521 | 29 | 2,723 | 0,009 |
| | Experimental | 30 | 1,27 | 0,699 | | | |
| Distinctions and Relationship between Scientific Theories and Laws | Control | 30 | 0,73 | 0,629 | 29 | 0,894 | 0,375 |
| | Experimental | 30 | 0,87 | 0,521 | | | |
| The Theory-Laden NOS | Control | 30 | 0,93 | 0,466 | 29 | 3,101 | 0,003 |
| | Experimental | 30 | 1,30 | 0,450 | | | |
| The Creative and Imaginative NOS | Control | 30 | 0,77 | 0,365 | 29 | 2,432 | 0,019 |
| | Experimental | 30 | 1,07 | 0,568 | | | |
| Social and Cultural Influences on Scientific Knowledge | Control | 30 | 0,87 | 0,571 | 29 | 1,516 | 0,136 |
| | Experimental | 30 | 1,13 | 0,776 | | | |

**Table 8** Percentages and frequencies of naive, transitional and informed views of NOS aspects of the experimental group before and after the intervention

| NOS aspects | Tests | Naive | | Transitional | | Informed | |
|---|---|---|---|---|---|---|---|
| | | f | % | f | % | f | % |
| The Empirical NOS | Pre-test | 8 | 26 | 21 | 70 | 1 | 3 |
| | Post-test | - | - | 14 | 46 | 16 | 53 |
| Distinctions between observation and inference | Pre-test | 14 | 46 | 15 | 50 | 1 | 3 |
| | Post-test | 1 | 3 | 20 | 66 | 9 | 30 |
| The tentative NOS | Pre-test | 7 | 23 | 16 | 53 | 7 | 23 |
| | Post-test | 5 | 16 | 10 | 33 | 15 | 50 |
| Distinctions and Relationship between Scientific Theories and Laws | Pre-test | 24 | 80 | 6 | 20 | - | - |
| | Post-test | 8 | 26 | 18 | 60 | 4 | 13 |
| The Theory-Laden NOS | Pre-test | 9 | 30 | 20 | 66 | 1 | 3 |
| | Post-test | - | - | 21 | 70 | 9 | 30 |
| The Creative and Imaginative NOS | Pre-test | 14 | 46 | 16 | 53 | - | - |
| | Post-test | 1 | 3 | 26 | 86 | 3 | 10 |
| Social and Cultural Influences on Scientific Knowledge | Pre-test | 20 | 66 | 10 | 33 | - | - |
| | Post-test | 3 | 10 | 20 | 66 | 7 | 23 |

**Table 9** Mean and standard deviation values of the experimental group

| Tests | N | X | Sd | df | t | P |
|---|---|---|---|---|---|---|
| Pre-test | 30 | 4,13 | 1,852 | 29 | -11,162 | ,000 |
| Post-test | 30 | 8,53 | 1,852 | | | |

between posttest scores of the experimental and control groups in favor of experimental group regarding "Distinctions between observation and inference" and "The Empirical NOS" aspects. In addition to that, there was a significant difference between pretest and posttest scores of the experimental group regarding these aspects (Table 10). As we examine table 8 for the development of PST understandings on these aspects, after the intervention no PST left with naive views on "The Empirical NOS" aspect and only one PST held a naive view on "Distinctions between observation and inference" aspect. These reveal that using documentary films had a positive effect on PST' NOS understandings on "The Empirical NOS" and "Distinctions between observation and inference" aspects. Observations are explanations of natural phenomena which are accessible to senses and can be observed by other individuals. But scientists do not have direct success to the most natural phenomena, they use scientific instruments and conduct experiments to generate empirical evidence and based on observations and experiments, scientists interpret and derive a conclusion which is called inference (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002; Lederman, 2007).

Since engaging students with laboratory activities; try to work as a scientist, conduct scientific investigations and experiments help them to improve their understanding about NOS (Wardani & Winarno, 2017; Prima, Utari, Chandra, Hasanah, & Rusdiana, 2018), watching scientists on work and discussing might have provided a development on PST understanding of NOS. For instance, on the 5. Documentary film Galileo documented the experiments and observations he made and observed the movement of Jupiter's satellites, and was seen to be influenced by the fact that there are objects that do not revolve around the world, and thus there are examples of such things that contradict the idea of the world as the center of the universe. Historical science stories help PST to connect with scientists and have the opportunity to see the examples of how scientific researches are conducted. (Laçin-Şimsek, 2019).

According to the results of the study, a significant difference was found on The Theory-Laden aspect of NOS between posttest scores of the experimental and control groups in favor of the experimental group and between pretest and posttest scores of the experimental group. As science is a human activity, it shouldn't be expected to be objective. Scientists', prior knowledge, philosophical perspectives, training, experiences, backgrounds beliefs, bias, values, and expectations can affect their studies. These may influence scientists' researches; what they observe, how they observe, and how they interpret their investigations. Since scientists aren't objective, their observations cannot be expected to be objective; their views depend on their theoretical perspectives (Lederman, 2007). PST had the chance to look at the lives of scientists like Newton, Teslathe, and Einstein more closely. They could observe that scientists are involved in their work discipline, scientific study and scientific knowledge as well as their personal lives and personal characteristics, and recognize that the prejudices of the scientists, their beliefs and their experiences could affect their decision-making processes and their scientific viewpoints, in the light of this aid to understanding theory-laden aspect of science (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002;

**Table 10** Mean and standard deviation values of NOS aspects before and after the intervention

| Groups | Tests | N | X | Sd | df | t | P |
|---|---|---|---|---|---|---|---|
| The Empirical NOS | Pre-test | 30 | 0,77 | ,092 | 29 | -4,942 | ,000 |
| | Post-test | 30 | 1,57 | ,104 | | | |
| Distinctions between observation and inference | Pre-test | 30 | 0,57 | ,568 | 29 | -5,887 | ,000 |
| | Post-test | 30 | 1,27 | ,521 | | | |
| The tentative NOS | Pre-test | 30 | 1,00 | ,695 | 29 | -1,904 | ,067 |
| | Post-test | 30 | 1,33 | ,758 | | | |
| Distinctions and Relationship between Scientific Theories and Laws | Pre-test | 30 | 0,20 | ,407 | 29 | -5,525 | ,000 |
| | Post-test | 30 | 0,87 | ,629 | | | |
| The Theory-Laden NOS | Pre-test | 30 | 0,73 | ,521 | 29 | -4,958 | ,000 |
| | Post-test | 30 | 1,30 | ,466 | | | |
| The Creative and Imaginative NOS | Pre-test | 30 | 0,53 | ,093 | 29 | -5,757 | ,000 |
| | Post-test | 30 | 1,07 | ,067 | | | |
| Social and Cultural Influences on Scientific Knowledge | Pre-test | 30 | 0,33 | ,479 | 29 | -6,595 | ,000 |
| | Post-test | 30 | 1,13 | ,571 | | | |

Vanderlinden, 2007). Owing to that experiences PST might have developed a better understanding on the tentative aspect of NOS.

The results indicated that on “The Creative and Imaginative NOS” aspect, a significant difference was found between posttest scores of the experimental and control groups in favor of the experimental group and between pretest and posttest scores of the experimental group. Even though science is based on observations of the natural world, creativity and imagination play a significant role in science. Science is not rational and orderly; scientists don’t always follow specific method to conduct their researches while generating scientific knowledge, this process contains creativity and scientists can use their imagination to fill the gaps in their studies (Lederman, 2007). With the documentary film of Tesla, the importance of creativity and imagination in science was mentioned by discussing exciting ideas and incomprehensible inventions. It was emphasized that scientists use their imagination and creativity to produce new ideas and that imaginative power occupies an exceptional place beside the methods and rules, showing that science is not only methodological (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002). Similarly, it can be said that the emphasis on the imagination that lies behind the theories of Einstein's behavior on macro dimensions influenced the development of the PST’ views in this aspect of science.

The results showed that there was no statistically significant difference between experimental and control groups on “Distinctions and Relationship between Scientific Theories and Laws” “Social and Cultural Influences on Scientific Knowledge” aspects. When the literature is examined, studies which have been conducted with samples at every level show that there are many conceptual errors about theory and law concepts, and that there are difficulties in understanding these concepts (McComas, 1998; Buaraphan, 2010; Deng, Chen, Tsai, & Chai, 2011; Göksu Aslan, Murat & Zor, 2016). It is a common misconception of individuals that there is a hierarchical relationship between theories and laws; with more supporting proof, scientific theories become scientific laws. According to this misconception, scientific laws are more secure than scientific methods and have a higher status than scientific methods (Lederman, 2007; McComas 1998). Contrary to this common belief, scientific theories and laws are a different kind of scientific knowledge and don’t change one into another. A scientific theory is an explanation of observable phenomena whereas a scientific law is a description of the relationship between observable phenomena (Lederman, 2007).

When the table 10 examined, it was found that there was a significant difference between pretest and posttest scores of the experimental group on “Distinctions and Relationship between Scientific Theories and Laws” aspect. This significant difference can be the effect of the following documentary films. This scientific knowledge were discussed especially in the Time Bending beyond the Universe documentary, paradigms and theories were explained, the points that theories and laws are different and that they will not convert into each other were underlined, in the Newton and Einstein documentaries, Newton’s laws and Einstein’s theories were explained to describe this scientific knowledge.

As it is mentioned before one of the two aspects that there was no statistically significant difference between experimental and control groups was “Social and Cultural Influences on Scientific Knowledge”. According to the literature, these two aspects, the social and cultural influences on scientific knowledge and the distinction between theories and laws, were more challenging to teach to PST than the other five aspects (Bell, Lederman, & Abd-El-Khalick, 2000). When the pretest and post-test scores of the experimental group are compared, there was a statistically significant difference in favor of posttest on "Social and Cultural Influences on Scientific Knowledge" aspect. Contrary to common belief, science affects and is affected by the culture in which it is embedded. Because science is a human enterprise and scientific knowledge is generated by humans; it can affect and be affected by the ethical, social, political, moral and religious aspects of a culture (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002). At the intervention the period of the scientists' lives was revealed with the documentary films, making it possible for the PST to become aware of the social and cultural values of the society in which science is produced. For example, the world was at war during the Einstein era, and in the period of Galileo, there was a prohibition of the view of the heliocentric model due to the dominant influence of the church. Besides this, it can be said that one of the factors influencing the change in the opinions of the PST is the mention of religion and science in the Avicenna and Al-Farabi parts, in particular, emphasizing that religious belief made a great contribution to the progress of scientific research at that time. Similar to this study, Ayar (2007) stated that science-technology-society lessons were used to study the influence of science teachers' opinions on the NOS, and it was concluded that the use of film sections and newspaper news in the lessons was successful in the relationship between science and social values.

The results of the study also showed that there is a statistically significant difference was found between posttest scores of the experimental and control groups in favor of experimental group on the aspect of "The Tentative NOS". Even though scientific knowledge is considered as absolute or certain, this knowledge can change through time, by new data or interpreting data with the light of new theoretical ideas (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002). Scientists based their growing understanding on empirical data that becomes more extensive with each new wave of technology (Sterling, 2009). Tentative NOS was emphasized by comparing Newton's physics and Einstein's physics and explaining why Pluto wasn't considered a planet anymore. It is also revealed in almost every documentary film that whatever the type of scientific knowledge is, it will not be specific, and that science can change in the light of new findings or reinterpretation of old data.

## 4. CONCLUSION

In this study, the effects of documentary films on PST' views about NOS was investigated. According to the results, there is a statistically significant difference between posttest scores of experimental and control groups (Table 6). Therefore, it can be concluded that teaching NOS with documentary films is an effective way to teach NOS.

When the aspects of the NOS are examined, the fact that the NOS is included in more than one documentary for each aspect, and that the same aspects are spread over a long period by giving the opportunity for them to be discussed through different examples in different weeks, is effective in changing the opinions of PST. According to the literature before the intervention, PST' opinions were resistant to change and therefore, long term applications are needed (Çil, 2010; Mulvey, Chiu, Ghosh & Bell, 2017). The pretest scores of PST showed that they have many misconceptions about NOS. In order to prevent this, education about NOS should begin in students' early years and supporting it with documentary films and sections from science history until undergraduate degree level will help to get rid of misconceptions.

Since NOS is based on different disciplines like science philosophy and science history, lessons at undergraduate level need to be given that is enriched with sections from science history and documentary films which focus on scientific works and scientists instead of theoretical ones. It can be suggested that documentaries and scientific videos like these should be used in not only NOS courses but also science lessons integrated with topics, and they should emphasize NOS in this way.

Presenting science in a way which includes stories, documentary films and the conditions that it has been made in, and criticizing it, will help to improve students' opinions about NOS. Making an effort to help them understand how problems exist instead of how to solve them will increase their curiosity about science, and it will make learning science easier.

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