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# Use of a Movie (Lorenzo's Oil) in Teaching Nature of Science to Preservice Science Teachers

**Fatma Taşkın Ekici**
Pamukkale Univeristy, Turkiye, ftekici@gmail.com, 0000-0001-7798-6021

"I do not know what I may appear to the world, but to myself I seem to have been only like a boy playing on the seashore, and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me."

(Isaac Newton)

**Abstract**: Today, learning environments are constantly getting developed and updated to make the teaching-learning process more active. Besides, tools that enhance learning in educational environments are also getting diversified. One of these educational tools is the movies that are based on real life stories. In addition to informing students about several biological topics and issues, the movie called Lorenzo's Oil handles the impact of a neurological disease on the social environment. The movie also informs the audience about science, scientists, scientific process skills and nature of science, and encourages the audience to think and reflect about these issues. The aim of this study is to investigate the effect of this movie, which covers a real-life story, on the teaching of science and nature of science elements of teacher candidates. For this purpose, the data of the study were collected through the VNOS-C questionnaire and reflective writings before and after a course in which the movie Lorenzo's Oil was included in the teaching process. At the end of the study, according to the findings obtained from the reflective writings and VNOS-C questionnaire, it was concluded that the views of the pre-service teachers on science and nature of science changed positively, and they were in the knowledgeable category at the end of the process.

**Keywords**: *Lorenzo's Oil, Nature of Science, Science, Teaching*

## Introduction

Understanding nature of science and issues related to nature of science is recognized as a vital component of scientific literacy around the world (American Association for the Advancement of Science [AAAS] 1990; Lederman and Lederman, 2014; Millar and Osborne 1998; Osborne et al. 2003; Wahbeh and Abd-El-Khalick 2014). Typically, "Nature of Science" refers to the epistemology and sociology of science, science as a way of knowing, or the values and beliefs inherent to scientific knowledge and its development (Lederman, 1992). In the studies conducted, it is emphasized that most of the science teachers do not have an adequate understanding of nature of science (Lederman and Lederman 2014). Teachers, who are supposed to develop students' views on nature of science, must first receive a good education on this subject and have a developed understanding of nature of science. Several studies have revealed that some science teachers have naive concepts and many misconceptions about nature of science (Akerson et al. 2009; Doğan and Abd-El-Khalick 2008; Guerra-Ramos et al., 2010). More time and effort is required to develop or determine the best model or approach to teach nature of science (Lederman and Lederman, 2014), and there is no consensus among both students and teachers about the characteristics of such a model or approach that can lead to a better understanding of nature of science. (Kartal et al., 2018). Another noteworthy point to consider is that preparing teachers for teaching nature of science is surely a prerequisite for helping students at any level develop understanding of nature of science. For this reason, it is vital for teachers to have an adequate understanding of nature of science and to have the ability to transfer this understanding to practice (Bilican et al., 2012).

Bell (2009) argued that even if it involves high level of questioning skills and experiences, having hands-on activities in teaching is not the same as teaching nature of science. Studies on how to teach nature of science indicated that this teaching should have certain features that can be classified as "explicit", "reflective" and "context". The explicit approach refers to the planning and implementation of instructions for the desired learning outcomes in nature of science teaching (Akerson et al., 2000). The reflective approach, on the other hand, includes providing opportunities for students to analyse activities for one of nature of science frameworks, to make connections between these activities and the actions of scientists, and to make inferences about scientific epistemology" (Abd-El-Khalick & Akerson, 2004). In the third approach to effective teaching of nature of science, the importance of context is also underlined (Clough, 2006). Abd-El-Khalick and Akerson (2009) pointed out that the term "explicit" is inherently related to curriculum, while the term "reflective" has instructional implications". However, because effective nature of science teaching requires both explicit and reflective approaches, it is quite good to combine these two approaches (explicit and reflective) (Scharmann et al., 2005).

Researchers in education field have attempted to examine and evaluate the effectiveness of different methods in nature of science teaching. Various studies on teaching nature of science have revealed that the explicit reflective approach is the most effective approach in developing both pre-service and in-service teachers' views of nature of science (Abd-El-Khalick and Lederman 2000a; Akerson et al. 2000; Bell et al. 2011; Matkins and Bell 2007; Morrison et al. 2009). According to Allchin (2013), on the other hand, the most effective method in teaching nature of science is the use of historical case studies (Radloff, 2016). There are also researchers who argue that explicit-reflective teaching is typically more effective than implicit teaching in nature of science teaching (e.g., Abd-El-Khalick and Lederman 2000b; Khishfe and Abd-El-Khalick 2002). In some other studies, it has been suggested that teaching nature of science can be more effective when context-specific activities are used rather than general activities (Çakmakçı 2012; Sadler, 2011).

Looking at the literature, in most of the experimental studies on teaching nature of science, various methods and tools have been utilized. Strategies such as research and inquiry-based laboratory experiments, argumentation-based teaching, discussion of socio-scientific issues, and inclusion of the history of science in the course content have contributed to the development of students' views on nature of science. Despite all these efforts for teaching nature of science, McComas, Clough, and Nouri (2020) asserted that it is complex and difficult to transform a content into solid plans for effective teaching and learning and stressed the importance of pedagogical content knowledge (PCK) about nature of science. Science teachers are also largely unaware of online resources dedicated to appropriate and effective nature of science teaching (McComas et al., 2020). In some studies, it is remarked that teachers are more dependent on science coursebooks and supportive course materials that do not focus on nature of science. Here, movies dealing with real life stories can be mentioned as a supportive course material (Banilower et al., 2013; Stake and Easley, 1978; Weiss, 1993; Weiss et al., 2003).

Teachers who really want their students to understand nature of science accurately regard nature of science as a vital aim of science education and often express this as an objective in their lesson planning in order to encourage student action towards this (Clough, 2011). These teachers may sometimes aim to engage their students with some activities (such as black box, puzzle solving, etc.) or reading exercises that only focus on the nature of science. Clough (2011) proposed that presenting science in a context related to daily life allows students to see what they have learnt as really related to science and to learn nature of science better. Nevertheless, such activities that would obviously draw students' attention to nature of science are not sufficient to teach nature of science. Clough (2011) also pointed out that within the context of laboratory activities, videos, reading assignments and interactive course presentations, questions should be incorporated as part of the lessons so that students will reflect on and better understand nature of science. In this study, in which we examined the effect of the movie Lorenzo's Oil on the views of teacher candidates about nature of science, this perspective proposed by Clough (2011) regarding questions was adopted and the participants were asked critical questions during the application.

In the literature, the most well-known activities used by researchers to teach nature of science include “Tricky Tracks”, “The Aging Teacher”, “The Tube” and “Water Generator” (Lederman & Abd-El-Khalick, 1998), “Mysterious Facts” (Lee & Fortner, 2007), “Einstein & Eddington” (Martin, 2008), and “Tangram” (Choi, 2004). Today, different materials are utilised in education in terms of methods and techniques, and it is believed that the learning environment is richer in this way. The abundance of these educational tools in learning environments and their appropriate use is directly related to an effective guidance and coordination of teachers. There are numerous activities chosen in parallel with the adapted approach in teaching nature of science (Taşkın-Ekici & Ekici, 2014). Movies are among the fundamental materials that enable students to use and develop their cognitive and psychomotor features effectively. (Demircioğlu, 2007). In addition, the fact that movies are used to enrich learning environments and to appeal to multiple senses is a direct result of enriching process of learning environments (Taşkın-Ekici & Ekici, 2014).

**Use of Movies in Teaching**

This study investigates the effect of the 1992 George Miller film Lorenzo’s Oil on the views of pre-service science teachers about nature of science in the Nature and History of Science course. Since the movie displays the characters’ efforts related to science and contains features about nature of science especially because of its scenario, it is believed to provide rich educational content to the course. Movies are effective teaching tools, partly because they appeal to both visual and auditory learners (Lipiner, 2011), and therefore, educational, and popular movies offer useful alternatives to traditional teaching methods when used appropriately. About two decades ago, Burkowski Jr. and Alvarino (2000) argued that students are accustomed to obtaining information from television and cinema, therefore use of films improves the learning environment. Studies indicating that movies affect social skills, durability of information, students' enjoyment of the course and academic success also provide information about the selection of movies, the production of special topics and their use in different learning levels (Yakar, 2013). Having students critically analyse and review films will enable them to become responsible consumers who can interpret the meaning of the process they are observing, rather than passive buyers.

Popular films have been used as educational tools for topics such as language (Wang and Zhang, 2012), vocabulary (Csomay and Petrovic, 2012), culture (Bu, 2012), intercultural management (Pandey, 2012), human rights (Banks, 2009), political science (Bostock, 2011) and history (Woelders, 2007). Hart (2011) revealed that movies can be used to help nursing students make connections between career paths and public health concepts. Laursen and Brickley (2011) suggested that documentary films help students learn some scientific materials and better understand the scientific method in general. Çayıroğlu (2014) remarked that carrying out a sociology course with movies gives students the field practice experience. According to Çayıroğlu, movies increase participation and interest in lesson, develop critical thinking, and ensure the durability of concepts and theories. Dubeck et al. (1995) found that inserting science fiction movies in basic science courses at university level helped many students improve attitudes towards science, and that watching movies improved their understanding of science as a process.

Audiences come with various (often unconscious) expectations about how a movie presents a real or fictional story. It is often assumed that films create a realistic, or at least a possible world, one that operates on the laws of nature and logic. Movies are compatible with what can be considered as a fact or possible experience in our own world (Barthes, 1982). Barthes (1982) defines this situation as the reality effect of movies. The visual and auditory language in movies allows for such an integration of the individual-environment, because besides dealing with scientific concepts, it displays characters living in a world that can be recognized and defined by students (Serra & Arroio, 2009). By making use of this audio-visual language explained by Serra and Arrorio, it is not only possible to increase the interest and motivation of students in science, but also to get them engaged in science and teaching and learning process; in this way more efficient communication and more effective learning can be achieved. More importantly, movies are actually a source of information that directly affects students' views, perceptions, and concepts about how science works or about scientists (Arorio, 2011).

Studies on the use of movies in education have indicated that films positively affect social skills, permanence of knowledge (Kumar, 1991, Duchastel et al., 1988), students' satisfaction and motivation related to the course (Kumar, 1991; Hagen, 2002), cognitive skills such as interpretation, critical thinking, problem-solving skills (Kumar et al., 1994; Hagen, 2002), and academic success (Yow, 2014). Movies, as visual materials that require the use of multiple senses, not only contribute to education, but also result in some basic outcomes such as critical thinking and problem-solving skills (Birkök, 2008). Wink (2001) used excerpts from several movies, including Lorenzo's Oil, in his general chemistry class. The movie (Lorenzo's Oil) preferred for this study was previously used in other studies focusing on the teaching of general chemistry and biochemistry courses (Wink, 2011; Pekdag & Le Marechal, 2010). In addition, some other films (e.g., Apollo 13, From the Earth to the Moon, October Sky, and The Girl with the Yellow Hands) were also incorporated in various university-level courses as is seen in several studies (Goll and Woods, 1999; Goll, Ley, and Nytes, 2008). After making use of the movies “Dr. Ehrlich's Magic Bullet” and “Me and Isaac Newton” as the basis for written assignments about the content and process used in chemical studies, Griep and Mikasen (2005) published a book compiling dozens of films that have the potential to be used in science classrooms (Griep and Mikasen, 2009). One of the most important factors determining the effectiveness of using movies in students' educational processes is the instructor's ability and willingness to discuss about the movie or clip before and/or after watching the movie in class (Aitken, 1994; Royce, 2002; Barnett & Kafka, 2007; Laprise & Winrich, 2010; Eick and King, 2012). Russell (2007) elaborated the procedures and steps to follow when inserting films in the lessons. In the model proposed by Russell, many issued such as film selection, the educational benefits of using films, the legal framework of the issue, and the steps to be applied in the course are examined in detail. With the development of technology, there is an increasing interest in the use of multimedia as a teaching tool integrated into the curriculum for science teaching in schools (Berk, 2009; Everhart, 2009; Mayer, 2001; Pace & Jones, 2009).

Videos can be utilized in flipped classrooms, where students access the videos before attending the course (Tucker, 2012). Champoux (1999) suggested that there are four different ways to use a film during teaching in a classroom including (a) before a theoretical discussion, (b) after a theoretical discussion, (c) repeatedly, in a way that discussions and film demonstrations repeat each other (watch-discuss-watch-discuss) (d) in the case when two different films about the same story are shown. (Champoux, 1999). Pandey (2012) also suggested a few different ways that can be used for the use of a film in teaching as follows:

- In one or two sessions of a lesson, the teacher can demonstrate some pre-determined key scenes from the movie and trigger discussions about specific theories, models, and topics.
- It is possible for the teacher to show the entire film before the theoretical sessions and to repeat selected scenes in class if necessary during the discussions.
- An introductory lecture can be provided by the teacher on relevant theories before the movie starts and then discussion about the movie and related theories can be performed.
- It is possible for the teacher to make use of the movies chosen as cases during the lesson and show some certain scenes from different movies to start discussions according to the predetermined planning.
- The teacher can require the students to watch some selected films as part of individual or group project assignments and to analyse these films considering relevant theories (Pandey, 2012).

The procedure we followed in our study in terms of movie use includes showing videos in class followed by discussion. The most important evidence of the contribution of using the movie "Lorenzo's Oil" in terms of teaching science and nature of science is the role attributed to science as the main topic in the movie. According to the scenario of the movie, when the Odone’s realize that their child has a disease that has not been extensively studied due to the very small number of patients, they undertake the responsibility to carry out intensive research and eventually become researchers themselves. The process regarding the inclusion of the film in the course content is given in detail in the following heading

**The Movie: Lorenzo's Oil**

Lorenzo's Oil is a 1992 movie directed and written by George Miller, based on real life. In the movie, it is possible to see several important figures such as Susan Sarandon, Nick Nolte and Laura Linney playing the leading roles. In the film, Lorenzo Odone, the child of Italian parents named Augusto Odone and Michaela Odone, who were in East Africa due to their duty in 1983 and actually lived in Washington, USA, suffers from a rare and incurable fatal disease for which the medical world is unable to find a cure. The movie displays the struggle of this helpless family for Lorenzo's survival.

The life of the family changes completely when their 5-year-old son, Lorenzo, suffers from a genetic disease called ALD (Adrenoleukodystrophy), for which no cure has yet been found. Odones, who visit doctors due to the nervous breakdowns Lorenzo has had at school and at home although he is a very calm child, learn that their child is diagnosed with ADL, a disease that leaves doctors hopeless, and that he has 2 years to live. Lorenzo survives thanks to the perseverance of his family. It is thought that the cause of this disease is the inability to digest unsaturated fats. As a result, the myelin layer around the nerves in the brain is broken down. ALD disease, an orphan disease seen in one in 20 thousand people, is observed in boys between the ages of 5-8 and arises from the dysfunction of the adrenal glands and cortisone deficiency. The disease that erodes the brain causes paralysis, blindness, and dumbness within one year. Learning that the disease is inherited and transmitted from the mother's X chromosome, the mother becomes very upset, and the other siblings haven't been diagnosed with such a disease before. When they learn that there is no cure for the disease, the family goes to many different places in the hope of recovery, but they can't get any bit of a positive response from the doctors they have consulted to. Lorenzo's parents, who have no medical training, search all the books on ALD to save their son, review scientific research studies and articles on the disease, fund medical conferences and finally reach great success. As a result of this extensive effort, they conclude that the damage of the disease to the brain is caused by dangerous fatty acids in the blood. The father Odone, through his library scans, finds a researcher who has dealt with a similar disease. Upon learning that this study reaches positive results with mice, he explains the treatment of the disease theoretically with the example of a tap, which leads to awareness on obtaining and structuring knowledge. Thanks to the oil they reach as a result of their endeavours and the massage they perform on Lorenzo's body, they manage to prevent the progression of the disease. Through this method, which is the outcome of an extraordinary effort, they become a glimmer of hope for both Lorenzo and other children with ALD. The majority of children having ALD disease, which has ceased to be an incurable disease starting from this date, are prevented from developing the disease thanks to Lorenzo's oil, and these children manage to win the struggle for life.

**Features of Nature of Science**

Chang, Chang, and Tseng (2010) compiled current statements about nature of science in science education research from the studies conducted between 1990 and 2007. According to the study of Chang et al. (2010), key proponents of this research area in science education (e.g., Lederman et al., 2002; Lederman, 1992; McComas, 1998) outlined the framework of several statements what they call as the 'consensus view' regarding nature of science (NOS). These are as follows:

**“The Tentative Nature of Scientific Knowledge:** *Scientific knowledge is both temporary and permanent.”, “***Observations and Inferences:** *Science is based on both observations and inferences. Both observations and inferences are driven by scientists' prior knowledge and perspectives on current science.”, “***Objective and Subjective Nature of Science:** *Science aims to be objective and precise, but subjectivity is inevitable in science.”, “***The Creative and Imaginative Nature of Scientific Knowledge:** *Scientific knowledge is formed from human imagination and logical reasoning. This formation is based on observations and inferences of the natural world.”, “***The Social and Cultural Embeddedness”:** *Science is a part of social and cultural traditions. Science as a human endeavour is influenced by the society and culture in which it is practiced.”,* **“Scientific Theories and Laws:** *Both scientific laws and theories can change. Scientific laws describe the observed or perceived generalized relationships of natural phenomena under certain conditions.”, “***Scientific Methods:** *There is no single universal step-by-step scientific method followed by all scientists. Scientists investigate research questions with prior knowledge, perseverance and creativity”. (Lederman et al., 2002).*

NRC (1996) and AAAS (1993) also made suggestions in order for students to learn about similar perspectives related to these issues. In 2013, the Next Generation Science Standards (NGSS Lead States, 2013) were released to the public with great anticipation and admiration. According to these standards, Nature of Science, or in other words, The Nature of Scientific Knowledge (Lederman & Lederman, 2014) is considered as a subset of the "Science Practices" and "Crosscutting Concepts" dimensions. Specifically, the Nature of Scientific Knowledge is believed to consist of eight understandings (NGSS Lead States, 2013). *These understandings related to Science Practice are as follows: (1) Scientific Investigations Use a Variety of Methods, (2) Scientific Knowledge is Based on Empirical Evidence, (3) Scientific Knowledge is Open to Revision in the Light of New Evidence, (4) Science Models, Laws, Mechanisms and Theories explain Natural Phenomena (5) Science is a Way of Knowing, (6) Scientific Knowledge assumes an Order and Consistency in Natural Systems, (7) Science is a Human Endeavor, and (8) Science Addresses Questions of the Natural and Material World.*

In this study, which was conducted to find out the reflections of pre-service teachers about a selected movie, a rubric developed by Lederman, Abd-El-khalick, Bell, and Schwartz (2002) was used in order to evaluate the views on nature of science (answers to the VNOS-C questionnaire items), and the dimensions that are in the scope of consensus view are taken into account.

## Method

In addition to this movie, the author has been using several different movies (e.g., The Physician) that provide content about nature of science in her classes for about ten years and observed that students regard these movies as effective and interesting learning resource. In this study, it is aimed to examine how preservice teachers perceive the selected movie Lorenzo's Oil as a teaching tool and the effect of film inclusion in the teaching process on the students' beliefs about nature of science. For this aim, the questions stated below are tried to be answered:

1. How preservice teachers perceive the use of the movie of Lorenzo’s Oil as teaching tool or resource?

2. What are preservice teachers' opinions about the movie and nature of science content relations?
3. How does the use of Lorenzo's Oil movie in preservice teachers' course content affect their beliefs about the nature of science?

**Research Design**

The main purpose of this study is to reveal the effects of incorporating a film (Lorenzo's Oil) including the elements of nature of science into the course on the views of pre-service science teachers about nature of science. For this purpose, the study was designed around action research as a research method. Johnson (2005) defines action research as the process of understanding and improving the quality of teaching in real classroom environment, and states that it is a type of research that is pre-planned, organized and can be shared with other relevant people. Action research is research method that aims to determine the measures to be taken to improve a situation by making a critical evaluation of the existing practice with the participation of practitioners and those who are party to the problem under the direction of expert researchers (Karasar, 1999, p.27).

One of the main purposes of action research is to improve a practice or to solve any problem that emerges during the practice by following scientific processes. Kemmis and McTaggart (1988) proposed that the action research process consists of planning, implementation (action), observation, reflection, revision of plans and re-planning. In the present study, planning, implementation (action), observation, reflection and evaluation stages were followed.

**The Lesson Process and Use of the Movie**

The researcher has been using Lorenzo's Oil and The Physician films for about 10 years in a seminar-cum-workshop format within the Nature and History of Science course in the science teacher training program, but this study specifically dealt with the film Lorenzo's Oil. This study mainly consisted of two piloting and one main applications. The piloting applications were carried out in the 2018-2019 spring semester (n=29), and in the 2019-2020 spring semester (n=32). The main application, which is the subject matter of this paper, was carried out with 12 science teacher candidates (consisting of 8 females, 4 males) in the 2020-2021 spring semester.

The researcher took part in the case study research as a practitioner. As summarized in table 1, in the first 7 weeks of the application process, the lesson was carried out based on sample cases regarding Nature of Science. In the seven-week-period, the course content covered the following topics: philosophy of science, definition and features of science, stages of history of science, epistemology, scientific knowledge and its features, nature of science and approaches to teaching nature of science, in-class teaching activities related to teaching nature of science. In the week following the theoretical part of the course, a short section (15-20 minutes) from another sample movie (The Physician) was demonstrated to the students, and the students were required to identify and note the highlighted elements related to the nature of science in the movie, and then asked to discuss it in class. This sample activity was performed to provide experience for the participants to analyze movies.

**Table 1**

*Course Content Flow Chart*

| Course Durations | Time Allocated | The Process and Actions |
|---|---|---|
| 1 | The first 7 Weeks | o Presentation of Course Content with Theoretical Content and Question and Answer Method |
| 2 | $8^{th}$ Week | o Movie analysis sample application<br>o VNOS-C pre-test |
| 3 | $9^{th}$-$10^{th}$-$11^{th}$ Weeks | o Preliminary Discussion (preparation to the film)<br>o Movie demonstration process<br>o Notes about movie analysis<br>• Discussion<br>• Nature of Science<br>• Dimensions of Nature of Science<br>• Myths<br>o Science and scientists<br>o Reflective Writing<br>o |
| 4 | $12^{th}$ Week | o Interviews |
| 5 | $13^{th}$ Week | o In-class discussions focusing on the entire movie as a whole<br>o VNOS-C post-test |

After the eighth week that done this sample movie watching activity, in the following weeks (in third duration of the course as seen in table 1) the movie Lorenzo's Oil was demonstrated in three parts. After each part, discussions were held on nature of science, the dimensions of nature of science, myths about nature of science, and science and scientists. Before each discussion, the pre-service teachers were given time to take notes about the film analysis, and then discussions were held. After the discussions, the participants were asked to create reflective writings about the movies they watched. In this study, which is a qualitative study, the data were collected through interviews and reflective writing.

**Participants**

The participants of the study consisted of 12 preservice teachers studying at science teaching department in the spring semester in the academic year 2020-2021 and enrolled in the Nature and History of Science course. The application involved the whole class, and the data were collected from the whole class and evaluated. The students participating in the study were given pseudonyms and their identities were kept confidential. The study was carried out in the institution where the researcher works in order to be able to control the accessibility and the operation of the process more easily.

**Data Collection**

In addition to the Views of Nature of Science questionnaire (VNOS-C), reflective writings and interviews for the movie Lorenzo's Oil were used to collect data regarding the pre-service teachers' views on nature of science. The movie analysis notes were put into reports, taking into account the topics covered in the course "Nature and History of Science". VNOS-C questionnaire was applied as a pre-test and post-test in data collection.

**Data Analysis**

In the analysis of the qualitative data obtained from the VNOS-C questionnaire, general qualitative data analysis approach was followed. As suggested by Miles and Huberman (1994), the data analysis process included the steps of repeatedly reading the answers, taking notes about the existing patterns and categories, and finally generating codes. In order to ensure validity and reliability in data analysis, the emerging codes were also checked by another researcher working in the field of nature of science and a consensus was reached on the codes (Creswell, 2007; Lincon & Gubba, 1985). Analysis of Views of Nature of Science questionnaire (VNOS-C): The rubric developed by Lederman, Abd-El-khalick, Bell, and Schwartz (2002) was used to create the participants' profiles about their views on nature of science.

During the analysis, the views of the participants about nature of science were examined under three main categories as “inadequate”, “adequate” and “knowledgeable” (Akerson & Abd-El-Khalick, 2009; Akerson, Cullen, & Hanson, 2009; Lederman, Abd-El -Khalick, Bell, and Schwartz, 2002). Inadequate view in this categorization refers to the misconceptions about nature of science. As an example, the participant who defined science as "absolute" was included in the category of inadequate. Adequate view refers to acceptable views on nature of science. A participant is classified in the category of adequate view when s/he does not support his/her opinion with detailed explanations or examples. For example, when a participant accepts that scientific knowledge is changeable but cannot explain how this change happens or does not support the explanation with examples, his/her view is classified as adequate. The category of “knowledgeable view” on nature of science indicates that the participant has acceptable views about the nature of science and supports these views with detailed explanations or examples. For example, the participant in the informed view category accepts that scientific information is changeable, but also states that this change will occur with the reinterpretation of existing data, through the changes in the perspective of the scientists or obtaining new data. The main difference between adequate and knowledgeable views is the depth in the explanations of the participants, the elaboration of the explanations and enrichment with examples.

In this study, the data collection tools were chosen in accordance with the qualitative nature of the study (Merriam, 2009). The data collection methods and tools included semi-structured interview, open-ended Views of Nature of Science questionnaire “VNOS-C” (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002), student reflective writings and interviews. Views of Nature of Science questionnaire: A questionnaire consisting of ten open-ended questions developed by Lederman, Abd-El-Khalick, Bell, and Schwartz (2002) was applied to investigate the participants' views on nature of science. The nature of science dimensions of each question in the Views of Nature of Science questionnaire (VNOS-C) are listed below (Table 2):

**Table 2**

*Analysis of the Items in the VNOS-C Questionnaire Regarding the Dimensions of Nature of Science*

| Dimensions of Nature of Science | VNOS-C Items |
|---|---|
| The Empirical Nature of Scientific Knowledge | 1, 2, 3 |
| The Tentative Nature of Scientific Knowledge | 1, 5, 6 |
| Subjectivity of Scientific Knowledge/The Theory-Laden Nature of Scientific Knowledge | 9 |
| The Creative and Imaginative Nature of Scientific Knowledge | 8 |
| Relationship of Observation- Inference in Science | 4, 7 |
| The Social and Cultural Embeddedness of Scientific Knowledge | 10 |
| Scientific Theories and Laws | 5 |

Open-ended questions were used so that the participants would not limit themselves and express themselves more easily (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002; Schwartz & Lederman, 2002; Schwarzt, Lederman, & Crawford, 2004; Akerson, Buzelli, & Donnelly, 2008). In addition, the researchers who developed the questionnaire suggested that face-to-face semi-structured interviews with participants about their answers to open-ended questions would provide more detailed information about people's views on nature of science (Lederman, Abd-ElKhalick, Bell, & Schwartz, 2002). For this reason, reflective writings and interviews with the pre-service teachers were used to learn in-depth understandings of nature of science in the process.

## Results

This study was carried out in order to see how the views of pre-service science teachers about nature of science changed with the use of the movie Lorenzo's Oil as a teaching material. In this section, the findings of the data obtained through the VNOS-C questionnaire, interview questions and reflective writings are presented. Content analysis method was used in the analysis of the data. Content analysis is defined as a systematic, iterable technique in which some words of a text are summarized with smaller content categories with coding based on certain rules (Büyüköztürk et al., 2008). Responses to VNOS-C measurement tool were classified as "*Inadequate*", "*Adequate*" and "*Knowledgeable*" (Rubba, Bradford, & Harkness, 1996). According to this classification, "Knowledgeable" refers to the contemporary perspective, "adequate" refers to the reasonable, appropriate perspective, and "inadequate" refers to the inappropriate traditional perspective. The data were analysed, frequency and percentage analyses were interpreted.

The answers of the pre-service teachers to the VNOS-C questionnaire before and after the application were evaluated with the help of rubrics and categorized according to the VNOS-C category management. The areas with the highest accumulation in each category value are exemplified in terms of pre-application and post-application data. Accordingly, the categories are presented in table 3.

**Table 3**

*VNOS-C Pre-Post-Test Analysis Comparison Chart*

| Views of Nature of Science Questionnaire (VNOS-C) | | Pre-Test | | | Post-Test | | |
|---|---|---|---|---|---|---|---|
| | | INAD | AD | KA | INAD | AD | KA |
| The Tentative Nature of Scientific Knowledge | n | 5 | 6 | 1 | 1 | 0 | 11 |
| | *(%)* | *(%42)* | *(%50)* | *(%8)* | *(%8)* | *(%0)* | *(%92)* |
| The Empirical Nature of Scientific Knowledge | n | 3 | 5 | 4 | 1 | 1 | 10 |
| | *(%)* | *(%25)* | *(%42)* | *(%33)* | *(%8)* | *(%8)* | *(%84)* |
| Inferential Structure of Scientific Knowledge | n | 10 | 2 | 0 | 3 | 1 | 8 |
| | *(%)* | *(%84)* | *(%16)* | *(%0)* | *(%25)* | *(%8)* | *(%67)* |
| Imagination and creativity in science | n | 6 | 5 | 1 | 4 | 1 | 7 |
| | *(%)* | *(%50)* | *(%42)* | *(%8)* | *(%33)* | *(%8)* | *(%59)* |
| The socio-cultural structure of scientific knowledge | n | 8 | 4 | 0 | 2 | 1 | 9 |
| | *(%)* | *(%67)* | *(%33)* | *(%0)* | *(%16)* | *(%8)* | *(%76)* |
| Law and theories | n | 8 | 3 | 1 | 4 | 1 | 7 |
| | *(%)* | *(%67)* | *(%25)* | *(%8)* | *(%33* | *(%8)* | *(%59)* |
| Subjectivity in science | n | 8 | 4 | 0 | 1 | 3 | 8 |
| | (%) | (%67) | (%33) | (%0) | (%8) | (%25) | (%67) |
| VNOS-C Total | n | 48 | 29 | 7 | 16 | 8 | 60 |
| | *(%)* | *(%57)* | *(%35)* | *(%8)* | *(%19)* | *(%10)* | *(%71)* |

**Notes:** *(INAD: Inadequate, AD: Adequate, KA: Knowledgeable)*

As seen in table 3, according to pre-test applications of the VNOS-C questionnaire applied to the pre-service teachers, it is found that in the dimension of the *tentative nature of scientific knowledge*, considering the statements of the preservice teachers, five pre-service teachers were in the inadequate category, six in the adequate category and one in the knowledgeable category. On the other hand, after the application, one preservice teacher was in the inadequate category and 11 were in the knowledgeable category. Regarding the *empirical nature of scientific knowledge*, in the preliminary application, three pre-service teachers were in the category of inadequate, five were in the category of adequate and four were in the category of knowledgeable, whereas in the post application, one student was in the category of inadequate and one student was in adequate category, and ten students were in the category of knowledgeable. In terms of the *inference in science*, while ten of the pre-service teachers provided answers in the inadequate and two of them in the adequate categories in the pre-applications; on the other hand, in the post-applications, three students answered in the inadequate, one in the adequate, and eight in the knowledgeable categories. In the dimension of *imagination and creativity in science*, six pre-service teachers were classified in the inadequate, five in the adequate, and one in the knowledgeable categories in the pre-application. On the other hand, four students gave answers in the inadequate, one in the adequate and seven in the knowledgeable categories in the post application. In terms of the *social and cultural structure of scientific knowledge*, eight of the pre-service teachers gave answers in the category of inadequate and four of them in the category of adequate, while in the post applications, two students gave answers in the category of inadequate, one student in the adequate category, and nine in knowledgeable category.

In terms of *laws and theories*, eight students who make up the majority of the pre-service teachers gave answers in the category of inadequate, three in the category of the adequate and one in the category of knowledgeable, while in post applications four students gave answers in the category of inadequate, one in the adequate and seven students gave answers in the category of knowledgeable. Finally, in the *subjectivity* dimension, in the pre-application, eight pre-service teachers were in the inadequate category and four in the adequate category, while in the final applications one student was in the inadequate category, three in the adequate category and eight in the knowledgeable category.

**Table 4**

*Preservice Teachers Views About the Empirical Nature of Scientific Knowledge*

| VNOS-C Management | Category | Example |
|---|---|---|
| **Before Application** | **Adequate** | ***S1:*** *...Science means reaching the right information. ....What makes science different from other research fields is that it is objective. In other areas, it can be interpreted differently. It varies from person to person. In science, this does not happen because if a piece of information is true, it is true… Yes, it is necessary… For example, if the corona vaccine is not tested, if they try to apply the vaccine they produce directly, many people may die. But thanks to experiments, human life is not unnecessarily at risk* ***S4:*** *....To me, science is the accumulation of studies that are systematically carried out in order to meet the needs of human beings and their going into research with a sense of curiosity in line with their needs during their life in nature. In short, it is an effort to understand nature and relate events...* |
| **After Application** | **Know-ledgeable** | ***S1:*** *....In my opinion, the most important difference of positive sciences such as Physics, Chemistry, Biology from other fields is that they are factual, concrete, verifiable and are fully related to life. Positive sciences are fully a part of human life. Positive sciences are the science that will help us the most in our daily life. For example, scientists explain friction with the coefficient of friction. .....Besides, a villager living in a village with a hard winter wears thick rubber boots in winter. He spills salt on the ground. In fact, a villager goes into the science of physics without being aware of it.*<br>***S4:*** *.... It is provable. It is concrete. Other fields are abstract. They are the thoughts reflecting the inner world of a person. They cannot be proven… Philosophy can change one's perspective. It can encourage thinking differently. In fact, with this aspect, philosophy can even indirectly benefit the positive sciences. In addition, religion can meet elements such as belonging and future anxiety in people. But the most important feature that distinguishes positive sciences from other fields is that it is concrete and verifiable.*<br>***S8:*** *..Experiment is testing the hypotheses established as a result of observations in a controlled way, that is, trying to prove the correctness of the hypothesis concretely… While there exist lots of abstract concepts in other disciplines; in science teaching, concrete concepts are more dominant. For example, about the change of state of matter, boiling and evaporating the water put on a stove is something that happens in real life. Teaching this subject with an experiment allows students to learn and never forget it. ,,,,,, It is absolutely necessary…... Experiment is the process of proving science. It is the process of validating the hypothesis. Experiment is the key to the door to science. ....* |

In table 4, which shows the "Empirical nature of scientific knowledge" from the VNOS-C questionnaire, the views of the pre-service teachers before and after the application were compared. When the views of the pre-service teachers are examined, it is seen that while a pre-service teacher created answers in the category of "adequate" for this question before the application, he gave answers in the category of knowledgeable after the application.

It is among the findings that while the pre-service teachers emphasized the correct knowledge, method, and systematic aspects of science before the application, after the application, curiosity, need, research method, the process and experiment were emphasized and detailed more (Table 4). This situation can be evaluated positively in favour of the implementation process.

**Table 5**

*Preservice Teachers Views About the Tentative Nature of Scientific Knowledge*

| VNOS-C Management | Category | Example |
|---|---|---|
| **Before Application** | **Inadequate** | ***S5:*** *I don't think it can change. because theories give more confidence as time passes… there are many reasons for this, maybe after a long time our current theory can be supported by too many people and circles….*<br>***S7:*** *Once scientists have developed a scientific theory, this theory never changes, but other theories may be put forward against that theory.*<br>***S8:*** *I think theories don't change. For example, Darwin put forward the theory of evolution as a result of many studies. And it is within the framework of common logic. If you do not believe in this theory, you can put forward another theory supporting with your own knowledge.*<br>***S3:*** *Of course there are theories. Sometimes it is just a theory that has been put forward. Once it has been proven, it will become a law. For example, according to research conducted on Mars, it is possible that there is water on this surface of Mars in terms of these possibilities. This is a theory because it hasn't been proven yet. Whenever one goes to Mars and arrives at the location mentioned, and a confirmation is received that there is water there, then this becomes a scientific law.* |
| **After Application** | **Know-ledgeable** | ***S7:*** *….I think that it can change because theories change over time. There are many reasons for this, maybe after a long time, I believe that the theory we have established may be inevitably affected in a negative way as a result of the depletion of some living things or some substances, and therefore it will change. Scientists' revealing new data may cause these changes…*<br>***S5:*** *Scientific theories are assumptions about something that is logical and possible. Like the big bang theory. Scientific laws, on the other hand, are things that can be proved by operations within the framework of logic. Like Newton's laws of motion. Both are logical things.*<br>***S8:*** *A scientific law is a general principle well supported and proven by observation and experimentation. Typically, scientific laws are a limited set of principles that coincide with experiments and observations in the historical records. The concept of scientific law is closely related to the concept of scientific theory. The law explains a certain phenomenon of nature… while doing this, it uses repeated experiments and reaches the same result…. Thanks to the developing technology, more repetitive experiments can be done, the process can be transformed into a more comprehensive one….* |

In table 5, which shows the "tentative nature of scientific knowledge" from the VNOS-C questionnaire, the views of the pre-service teachers before and after the application were compared. When the opinions of the pre-service teachers are examined, it is seen that while a pre-service teacher gave answers in the category of inadequate for this question before the application; he gave answers in the category of knowledgeable after the application. The pre-service teachers attempted to present evidence that scientific knowledge and laws are definite and unchangeable before the application; on the other hand, after the application, they stated that scientific knowledge, including laws and theories, may change due to the viewpoint of scientists, the reinterpretation of existing data, and the possibility of obtaining new data thanks to new technologies. In addition, it is seen that the explanations in the last application were presented with more details and examples. This situation reveals the positive effect of the application process.

**Table 6**

*Preservice Teachers Views About Inference in Scientific Knowledge*

| VNOS-C Management | Category | Example |
|---|---|---|
| **Before Application** | **Inadequate** | ***S3:*** *Scientists have carried out various observations and experiments in order to find out the structure of the atom…. As a result, models have been put forward.* ***S12:*** *Scientists have been influenced by the proposed structure of the atom in order to decide what the atom looks like. According to Dalton, the atom is defined as a very dense and filled sphere. Thomson likened the atom to a raisin cake.* |
| **After Application** | **Know-ledgeable** | ***S12:*** *…with the importance and precision of scientific knowledge; It is seen that it is not possible to talk about a single scientific method and sequenced steps of this method in the process of creating scientific knowledge. Because of the existence of many different methods in many different branches of science, scientists do not use a strict scientific method to solve all problems;….In this context, it can be said that scientific knowledge is not precise and is not created as a result of a single and universal method followed step by step.* |

In table 6, which shows the "Inference in scientific knowledge" from the VNOS-C questionnaire, the views of the pre-service teachers before and after the application were compared. When the views of the pre-service teachers are examined, it is seen that while a pre-service teacher gave answers in the category of inadequate for this question before the application, he gave answers in the category of knowledgeable after the application. It is seen that the ideas of the pre-service teachers before the application mostly reveals that the scientists defend the knowledge as a result of experiments and observations and according to the situations they face.

Accordin to table 6, after the application, it was revealed that the pre-service teachers realised that scientists cannot observe every phenomenon in the nature one-on-one and accordingly they make inferences as a result of the observations. After the application, it is seen that the pre-service teachers elaborated and exemplified their views. This situation is positive in favours of the application.

**Table 7**

*Preservice Teachers Views About Imagination and Creativity in Science*

| VNOS-C Management | Category | Example |
|---|---|---|
| **Before application** | **Adequate** | ***S9:*** *Scientists firstly focus on a problem and then use their imaginations about the factors that cause this problem, check the data with wonder, look at the same problem differently, and approach the same problem with different human profiles. In this way, they will be able to reach a hypothesis. They approach the problem with these hypotheses they have established, if their hypotheses are wrong, they stop and think again at this stage, find out what could be wrong, where and what should be different, and apply it. And if their hypothesis this time turns out to be correct, I think they can plan to get it in different ways by looking at it in different ways from the beginning this time.* |
| **After application** | **Know-ledgeable** | ***S9:*** *...scientists use their creativity by transforming science into a creative discovery after reaching scientific knowledge. Unless the magnetization system used in the maglev train turned into an invention, it would only remain as a piece of information. But creative-minded scientists adapted this knowledge for real-life use and invented the maglev train. This could only happen through creative thinking.* |

In table 7 showing "Imagination and creativity in science" from the VNOS-C questionnaire, the views of the pre-service teachers before and after the application were compared. When the views of the pre-service teachers are examined, it is seen that while a pre-service teacher created answers in the category of "adequate" for this question before the application, he gave answers in the category of knowledgeable after the application. The pre-service teachers emphasized the effect of creativity and imagination on science and science elements and the importance of creativity in the restructuring the process of science before the application. After the application, the pre-service teachers talked about the existence of imagination and creativity in science in every step of science and all its processes, and they supported it by giving explanatory examples.

In table 8, which shows the "Socio-cultural structure of scientific knowledge" from the VNOS-C questionnaire, the views of the pre-service teachers before and after the application were compared. When the views of the pre-service teachers are examined, it is seen that the majority of the pre-service teachers created answers in the category of inadequate before the application, while they formed answers in the category of knowledgeable after the application.

While the pre-service teachers stated that science was not affected by the society they lived in before the application, and that the science process stood in a different place from the values and views of the society, the majority of the pre-service teachers were evaluated in the category of knowledgeable after the application and they explained the process by giving examples that science and society affect each other at the same rate. This situation can be interpreted as a positive effect of the implementation process (Table 8).

**Table 8**

*The Socio-Cultural Structure of Scientific Knowledge*

| VNOS-C Management | Category | Example |
|---|---|---|
| **Before Application** | **Inadequate** | ***S2:*** *....People can look at the same event from different angles depending on their lifestyle. However, science is independent of the behaviours and perspectives of societies… However, because different groups believe that their hypotheses are true and that they try to be dominant, they make different explanations. This situation is independent of the values of the society in which they live….* |
| **After Application** | **Know-ledgeable** | ***S6:*** *…I think that social and cultural values have a great influence on science. Because if we consider the past, observatories were destroyed, considering that they were against the society. Maybe if those observatories weren't destroyed and scientists weren't murdered, we would be in a better position in astronomy now than most countries. I think this would be one of the best proofs of the impact of sociocultural judgments on science.* ***S6:*** *I think that science is influenced by social and cultural values, but it is still universal. I can give the example of Galileo. Galileo claimed that the heliocentric system with his telescopic examinations and detected 4 satellites of the planet Venus. However, the social and cultural environment in which he lived at that time found his discovery contrary to Christian principles and prevented him on the grounds that his views were against the Pope. They wanted to prevent him from dealing with science and gave him house arrest. Galileo's understanding of science is hindered, but what he does in the name of science is universal. Today, the accuracy of the heliocentric system he discovered is still accepted.* |

**Table 9**

*Law and Theories*

| VNOS-C Management | Category | Example |
|---|---|---|
| **Before Application** | **Inadequate** | ***S4:*** *A scientific law is a scientific theory that has been proven with certainty. A scientific theory is a scientific proposition that has not yet been proven. A scientific law is a general principle well supported and proven by observation and experimentation. … The concept of scientific law is closely related to the concept of scientific theory. Typically, laws make more limited predictions about the world than theories.* ***S5:*** *…one is just a theory, one is now proven and has become a law. For example, according to research conducted on Mars, it is possible that there is water on a surface of Mars concerning some possibilities. This is a theory because it hasn't been proven yet. Whenever one goes to Mars and arrives at the location mentioned, and a confirmation is received that there is water there, then this becomes a scientific law.* ***S9:*** *....While the theory explains the phenomenon, the law proves the cause-effect relationships in the phenomenon. Scientific law is called scientific theory that has been proven definitively. A scientific theory is a scientific proposition that has not yet been proven.* |
| **After Application** | **Know-ledgeable** | ***S5:*** *....Theories are open to change, and laws, like theories, are also open to change. In addition, although scientific laws are testable, scientific theories cannot be tested directly. Thus, theory and laws are different types of scientific knowledge in terms of meaning and function.* |

In table 9 showing "Laws and Theories" from the VNOS-C questionnaire, the views of the pre-service teachers before and after the application were compared. When the views of the pre-service teachers are examined, it is seen that the majority of the pre-service teachers created answers in the category of inadequate before the application, while they formed answers in the category of knowledgeable after the application. While it is seen that the pre-service teachers expressed theory and law as a hierarchical structure following each other before the application, it is noteworthy that after the application, they said that the two concepts are independent from each other, and both are reliable concepts. This is seen as a positive reflection of the implementation process.

**Table 10**

*Subjectivity in Science*

| VNOS-C Management | Category | Example |
|---|---|---|
| **Before Application** | **Inadequate** | ***S3:*** *Scientists may have found different remains. Scientists who believe that it was the result of a volcanic eruption may have previously found the remains of a volcanic eruption on earth. The other group of scientists may have discovered the existence of meteorites from outer space that do not exist on earth. So two groups of scientists may have found different remains…*<br>***S8:*** *…When scientists work with scientific data, they are not affected by their past, culture, belief…. they only focus on the work they do and its utility….* |
| **After Application** | **Know-ledgeable** | ***S8:*** *Scientific knowledge involves subjectivity. The theories, beliefs, prior knowledge, education, experiences, and expectations that scientists have affect their work. All these factors that make up the mental background or perspective of scientists affects what they identify as a research problem, how they continue the research, what they observe and how they interpret their observations.* |

In table 10 showing "Subjectivity" from the VNOS-C questionnaire, the views of the pre-service teachers before and after the application were compared. When the views of the pre-service teachers are examined, it is seen that the majority of the pre-service teachers created answers in the category of inadequate before the application, while they formed answers in the category of knowledgeable after the application. Considering the issue of subjectivity, the pre-service teachers reported that scientists are objective, and they are not affected by their personal beliefs and culture before the application. After the application, they stated that scientists have some value judgments like other people and can be affected by these values even while following a scientific process.

It has been observed that the inadequate and incorrect knowledge of the pre-service teachers about the nature of science before they started using the movie Lorenzo's Oil as a teaching material for the teaching of nature of science, that is, at the beginning of the application, increased to a adequate and knowledgeable level after the movie was demonstrated, discussed, and after the reflective reporting process, that is, at the end of the application. The pre-service teachers stated that with the movie they watched, their perceptions of science and nature of science were structured more meaningfully, their interest in this subject increased, and they were able to establish a relationship between nature of science and daily life.

**Preservice Teachers Perceptions about the Content of Lorenzo's Oil Movie**

The findings obtained from the reflective writings created by the participants after the discussions carried out during the viewing of the movie "Lorenzo's Oil" were analyzed by categorizing them according to the dimensions of nature of science. Data analysis was conducted as suggested by Miles and Huberman (1994), reading the answers repeatedly, taking notes about the determined categories, and selecting samples by creating codes to represent the categories. In order to ensure validity and reliability in the data analysis, the codes created were also checked by another researcher working in the field of nature of science and a consensus was reached on the codes (Creswell, 2007).

**Table 11**

*Analysis of The Lorenzo's Oil Movie According to Nature of Science Dimensions*

| |
|---|
| **1. The Tentative Nature of Scientific Knowledge:** |
| **a.** *Lorenzo first gets sick, and they take him to the doctor, it is said that children with ALD would die within 2 years, but with the efforts of the family and various methods tried* |
| **b.** *Lorenzo lives much longer.* |
| **c.** *It is stated that in people with this disease, the myelin sheath gets rotten and cannot be repaired but in Lorenzo, the damaged organs are able to work again, albeit partially.* |
| **d.** *The doctor indicates that the development process of science is 8-10 years.* |
| **2. Scientific Knowledge is Based on Evidence from Experiments and Observations** |
| **a.** *The family has taken him to a lot of doctors since the child first gets sick. And they try all the methods the doctors tell them to do. For example, they constantly have a fat-free diet to reduce the rate of fat in the blood. Blood values are observed at regular intervals.* |
| **b.** *In a meeting attended by many doctors and scientists, they observe Lorenzo's condition as a subject, asking what he can and cannot do (for example, can he walk?).* |
| **c.** *His family is trying the oleic acid diet on Lorenzo.* |
| **d.** *Euric acid is decomposed by a doctor in the laboratory, and they observe its use for Lorenzo's treatment.* |
| **e.** *They do experiments on animals to produce myelin sheath.* |
| ***3. Subjectivity:*** |
| **a.** *The first doctor they met says that scientists can make mistakes and that their perspectives may differ.* |
| **b.** *Lorenzo's father says that they need to learn all sciences such as genetics and biochemistry to solve the ALD disease.* |
| **c.** *The association president says to the family that there is no cure, that they should believe what the doctors say, that it is destiny and that they have lost another child with this disease before* |
| **d.** *The fact that the woman selling fruits and vegetables lost her first child due to this disease but was able to save her other child from the disease with the method Lorenzo's family found, is an example of the dimension of subjectivity.* |
| **e.** *Some scientists put themselves in Lorenzo's parents' shoes, empathize and feel sorry for them.* |
| **f.** *At the meetings at the ALD foundation, they tell each other about the different problems that each family goes through.* |
| ***4. The Creative Nature of Scientific Knowledge:*** |
| **a.** *Lorenzo's father models the structure of oil chains with paper clips in the library. He tries to grasp the working principle of oil chains by making long oil chains.* |
| **b.** *The father has a dream about a single enzyme's being effective, and he comes up with ideas on it.* |
| **c.** *They use the results of experiments on Polish rats to treat Lorenzo.* |
| **d.** *The production of oleic acid and erucic acid can also be in accordance with the creative nature.* |
| **5. The Social and Cultural Structure of Scientific Knowledge:** |
| **a.** *After the family learns about the disease, they go to many hospitals and talk to many doctors. They go to Boston for treatment.* |
| **b.** *In addition, when they first find out about the illness, they go to the church and pray.* |
| **c.** *In the movie, a story that starts in Africa, a British mother and relatives living in Italy are mentioned.* |
| **d.** *The mother and the father do research as if they are scientists.* |

| | |
|---|---|
| ***e.*** | *The nurses who take care of Lorenzo at home, tired of his crises, give up, and then his mother calls her friend Omori in Africa. He also takes very good care of Lorenzo.* |
| **6.** | **Observations, Inferences and Theoretical Topics in Science:** |
| ***a.*** | *When they learn about the condition of the Polish rats, they infer that they should add another fat to the diet.* |
| ***b.*** | *His father, inspired by the kitchen sink, concludes that despite the decrease in the amount of fat Lorenzo eats, the diet they carry out does not work, which still increases the fat ratio in the body. So they consider changing the treatment method.* |
| ***c.*** | *When an improvement cannot be observed during Lorenzo's stay in the hospital, the family continues the treatment at home.* |
| **d.** | *As a result of extensive research they have done in the library, they draw inferences from new information by sharing and discussing with each other.* |
| **7.** | **Scientific Theories and Laws:** |
| ***a.*** | *ALD is a maternally transmitted disease seen in boys aged 5-10 years.* |
| ***b.*** | *Women are only carriers.* |
| ***c.*** | *The saturated fat rate in the blood is very high and ALD patients cannot secrete the enzyme that dissolves these fats.* |
| ***d.*** | *This disease erodes and rots the myelin sheath. The brain structure is deteriorated and cannot be repaired again.* |
| ***e.*** | *They attribute Lorenzo's being very active to hyperactivity.* |
| ***f.*** | *Many scientists' speeches and presentations of different ideas in a committee attended by the family are included in the scientific theories step.* |
| ***g.*** | *Despite all that has been said, the family finds the cure and they become a hope for those who got sick after him. Because the sooner the treatment of the disease begins, the sooner the response is received.* |

NoS and dimension examples from the movie content that given by the preservice teachers are summarised are summarised in table 11. The findings obtained by reflective writtings are in agreement with the "knowledge" and "adequate" categories obtained in the VNOS-C post-application of the pre-service teachers, and the examples and statements are viewed as have meaningful relation. During the discussions following the process of movie demonstration, the pre-service teachers pointed out that this method is very interesting and related to life, therefore, materials such as movies used in teaching nature of science have immersive and attractive effects while structuring the learning process.

## Discussion and Conclusion

This study was conducted to reveal how pre-service teachers' views on the nature of science were affected after the use of Lorenzo's oil movie as an in-class learning material. For this purpose, the VNOS-C questionnaire was applied to the pre-service teachers as pre- and post-tests, and at the end of the process, together with the post-test application, the results of the reflective writing containing the analysis of the movie Lorenzo's oil and the opinions of the pre-service teachers on the subject were obtained. Since the data obtained from the participants in this study were analysed in a qualitative design, it is not possible to generalize the findings. Therefore, the findings obtained from 12 student teachers participating in this research were interpreted without generalization.

According to research results, the pre-service teachers showed the biggest improvement in the tentative nature of scientific knowledge and the empirical nature of scientific knowledge between pre- and post-applications, but they also made a noticeable improvement in other dimensions. So, the implementation process made positive contributions to the views of teacher candidates on nature of science. These results show similarity with the results of some other studies in the literature (Abd-El-Khalick & Lederman, 2000; Arı, 2010; Akerson & Donelly, 2008; Turgut, 2009; Tufan, 2007; Abd-El-Khalick and Akerson 2004; Özdemir G., Akcay H., 2009 and Tasar, 2006)

As a result of the reflective writings created by the pre-service teachers about the movie, the preservice teachers stated that there was a process in which they got a lot of support and made sense of the transition to the knowledgeable category from the inadequate category in which the participants have misconception about the dimensions of the nature of science. They stated that they learned to recognize and make sense of very different educational facts from the movies they watched for various purposes in their daily lives, and that they learned a lot of while analyzing. It is remarkable that almost all of the pre-service teachers noticed the common points according to the results of the reflective writings and they interpreted the dimensions of nature of science with the same examples. From this point of view, the use of the movie Lorenzo's Oil in teaching Nature of Science reveals that is useful as a teaching material.

The movie Lorenzo's Oil was evaluated by the pre-service teachers as a film about how science and scientists are affected by cultures, social environment and needs. The pre-service teachers expressed why their previous teachings were resistant and how this affected their tendency to examine their behaviour. The discussions after this movie were mostly focused on the structure and history of science, how it was affected by social and cultural structures, and it was concluded that an absolute truth could not be reached as a result of the discussions performed in the lessons. It was observed that the pre-service teachers listened to each other more carefully, valued each other's ideas more while discussing.

One of the most important feedback leading to this conclusion is that the pre-service teachers thought that this movie was produced specifically to teach nature of science. As a result of the feedback received from the pre-service teachers, it was understood that the movie Lorenzo's Oil was quite effective in the way the pre-service teachers adapt to and perceive nature of science. After watching Lorenzo's Oil, the discussions among the pre-service teachers mostly focused on science, the way scientists work, subjectivity, the changeable nature of science, and the way science is affected by the social and cultural environment. The pre-service teachers discussed the differences between their previous knowledge and the practices they learned and created new inferences and teachings for themselves. Discussions among pre-service teachers encouraged them to develop skills such as interpreting, discussing and defining, and enabled them to use these skills actively. For this reason, it is believed that the use of movies such as Lorenzo’s Oil in teaching nature of science will be beneficial at different stages of education. In the theoretical analysis study done by Arrorio (2011), in which the suitability of the content of the movie Lorenzo's Oil for use in teaching the nature of science was discussed, it was stated that Lorenzo’s Oil would be useful for learning about topics like nature of science.

In the light of the data obtained from the pre-service teachers, it was concluded that especially the movie Lorenzo's Oil can be used to gradually construct and use the information about nature and dimensions of science, and movies can be used as teaching materials for pre-service teachers. As a result, it can be suggested that the movie Lorenzo's Oil, which was used as a teaching material in this application, contributed positively to the views of the pre-service teachers on nature of science.

Considering the results of this study, it is expected to be an example for researchers and teachers who will use it as learning material or resource in learning environments in the future. In addition, researchers can use different films as teaching materials or resources, depending on the content, and integrate them into the learning process in different ways. In the process of using movies as teaching materials, the effects of students on different skill areas such as critical thinking skills and creative thinking skills can be examined.

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**Corresponding Author Contact Information:**

**Author name**: Fatma TAŞKIN EKİCİ

**Department**: Science Education Department

**Faculty**: Faculty of Education

**University, Country**: Pamukkale University, Turkiye

**Email**: ftekici@gmail.com

**ORCID**: 0000-0001-7798-6021

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